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Radio-Activity and Radium.

By W. A. SHENSTONE, F.R.S.

I.

WE owe the discovery of radio-activity, and therefore that of radium, to an accident, though the phenomenon itself might almost be said to be a common one. Radio-activity was first noticed by M. H. Becquerel, who, stimulated, perhaps, by Röntgen's brilliant discovery of the X rays, was looking, in 1896, for yet other new radiations.

The accident was as follows: There is a salt known as potassium and uranium sulphate which, when it is exposed to sunlight, becomes for a moment self-luminous, and Becquerel was studying this phenomenon photographically.

His experiment consisted in placing crystals of the salt above photographic plates well protected from light by means of black paper, and then exposing the salt, which was outside the black paper, to the direct light of the sun. When he did this it became evident that some radiation or some emanation was produced which could penetrate the paper, for the photographic film immediately below the salt was so acted upon that when the plate was developed he obtained a silhouette of the crystals more or less like that shown in fig. 1, though this particular silhouette was given by a little radium bromide, and not by the uranium salt studied by Becquerel.

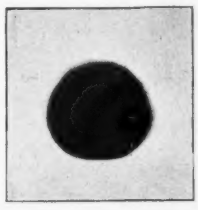


FIG 1.—*Silhouette given by Radium,*

One day, just as everything was ready for an experiment, clouds covered the sun, and Becquerel put away his plates with the crystals upon them, thinking them spoilt. Several days afterwards he developed the plates and found to his surprise that the silhouettes were particularly strong ones. He found, in short, that the sun was not needed to stimulate the salt; that this latter, without any such stimulant, radiated or emitted something which was able to penetrate black paper and act like light on a sensitive photographic plate. He found as the result of further experiments that this was no temporary quality of the salt. It persisted for days and months, and, as he discovered subsequently, even for years. Further, the same power was possessed by other uranium salts and by the metal uranium. Anyone who can take photographs can verify all this for himself quite easily.

The radiations thus discovered by Becquerel are called "Becquerel Rays." They resemble the Röntgen rays in many respects, and at one time were regarded as due to Röntgen rays. Thus, they cause damp dust free air to deposit fog, make air conduct electricity, will pass through such substances as paper, glass, paraffin, quartz, sulphur, Iceland spar, and thin layers of metal even more freely than Röntgen rays, and they cannot be reflected, refracted, nor polarized like the waves of which ordinary light is composed. It was found, further, that they are not homogeneous, but consist of several different radiations which can be filtered off from each other as it were, and can then be distinguished by their separate characteristics.

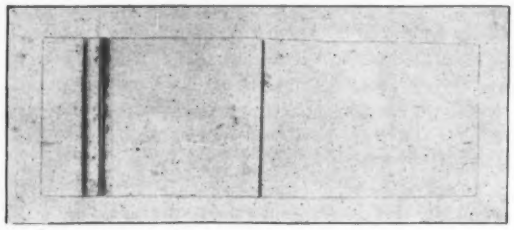
Bodies which emit these remarkable radiations are said to be "radio-active." As we shall see presently, other metals besides uranium are radio-active, and also the waters of some springs, as, for example, the waters at Bath, and even solid earth.

Becquerel's great discovery soon proved prolific. It suggested to Madame Sklodowska-Curie the idea that the great radio-activity of specimens of pitchblende, which exceeded that of the uranium present in them, must be due to special constituents, and so in her hands and those of others led to the discovery of polonium, radium, and actinium. And the remarkable properties of these new substances in their turn have started new ideas or revived old ones in several departments of science.

Madame and Monsieur Curie and their colleague, M. Bémont, discovered polonium and radium, and M. Debierne was the discoverer of a third substance of the same class, actinium. The method of working was to separate the components of the pitchblende, which is a very complex mineral, and to study the radio-active power of each constituent. The results obtained with the bismuth and barium from this mineral arrested attention, and presently it was found that the former was associated with the sub-

XUM

stance now called polonium, and the latter with the radium which plays such an important part in modern science. Neither polonium nor actinium have as yet been isolated in the form of a salt. The former in many ways resembles bismuth, and its nature still remains doubtful. Radium, on the other hand, yields salts—*e.g.*, a bromide, a chloride, and a nitrate. Its combining weight has been fixed by Madame Curie at 112·5, and 225 is suggested for its atomic weight. It exhibits a definite flame spectrum, which has been recorded by Messrs. Runge and Precht, and which is given in fig. 2, whilst its spectrum in the ultra violet has been studied by Sir William Crookes and others, and affords a means of identifying it.



d cb *a*

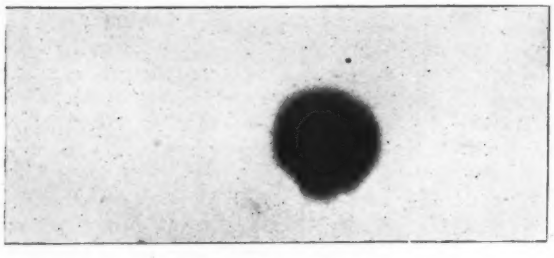
FIG. 2.—The Flame Spectrum of Radium.

The line *a* has the wave length 4826, *b* 6329, *c* 6349, *d* 6653. There are bands about *b c* and *d* as shown above.

Radium is generally regarded as an element, but as the total quantity of the pure radium salts yet made would be insufficient to fill a small egg cup, this statement must still be taken with some reserve. The so-called pure salts of radium possibly may be mixtures, but, for the present, in the absence of any evidence to the contrary, we may assume them to be salts of a new and peculiar elementary substance radium.

Radium the element has not been isolated. Its salts are so valuable, and the process of separating it probably would be so wasteful, that it seems unlikely anyone will attempt to prepare elementary radium at present.

The process of purifying a radium salt has not been very frequently described, but it is simple enough in principle. The raw material is the residue left after the uranium has been extracted from pitchblende. A ton of this material suitably treated may yield 10 or more kilograms of a mixture consisting chiefly of the sulphates of barium, lead, iron, and calcium, with a trace of radium. This is converted into carbonates by heating it with a solution of carbonate of soda, and the carbonates are dissolved in hydrochloric acid, which converts them into chlorides. The lead and iron in the mixture of chlorides thus produced are got rid of by means of sulphuretted hydrogen and ammonium sulphide, and the remaining barium, calcium, and radium are reprecipitated as carbonates, again converted into chlorides, and then washed with strong hydrochloric acid to remove the calcium chloride. The residue consists of barium chloride containing a trace of radium chloride. This is dissolved in hot water and allowed to crystallize partially. The crystals, which contain most radium, are separated from the liquid portion, and the latter is then evaporated to recover the remaining salt, and each of the two portions thus produced is similarly fractionated. By systematic work of this kind products were obtained first nine hundred times as radio-active as uranium, then five thousand times as active, then fifty thousand times, and at last, it is said, a million times as active as the standard substance, the removal of the barium salt at the later stages being facilitated by using solutions of hydrochloric acid in place of water for dissolving the mixture of barium and radium chloride.



B A

FIG. 3.—Radiographs of radium salt and uranium taken simultaneously.

Some idea of the difference between the activity of uranium salts and of radium may be got from fig. 3. On the reader's right is the silhouette A, given by one-sixth of a grain of radium in fifteen minutes. The area about the faint dark mark above B a little to the left of this shows the effect of a much larger quantity of a uranium salt, the two being exposed side by side over the same plate. The uranium salt, as will be seen, gave no sensible result at all. The small dark mark above B was added to indicate the centre of the area exposed to the uranium.

The salts of radium, in their ordinary reactions, resemble those of barium rather closely, but in other respects they are remarkably different. Thus, they are visible in the dark, and continuously evolve heat; so that a heap of a radium salt is always hotter than the air around it. So great is the amount of heat evolved that a gram-atom of radium gives out in a year as much heat as a gram-atom of hydrogen when it is burnt in the oxyhydrogen flame, and, moreover, as far as we know, the radium would go on giving out heat at this rate for many centuries. Its powers are destroyed to a great extent if it is strongly heated (see emanation), but are recovered spontaneously after a few weeks on cooling.

Radium, or rather its radiations, are very destructive. A piece of cambric placed above a box containing a little radium salt was found by Lord Blythswood to be pierced with holes after two or three days. A photographic film exposed to one-sixth of a grain of radium bromide in the author's laboratory for four hours by Mr. W. D. Rogers (who has kindly prepared many of the figures given in this article) yielded no silhouette because the film was completely disintegrated and its remains washed away during the developing process; and the caustic powers of radium salts, as is well known, are thought likely to prove useful in surgery, and have sometimes produced very unpleasant effects when specimens of the salts have been kept too long near the human body. Its power of making air conduct electricity is shown by the way in which a tassel of silk electrified by rubbing with india-rubber collapses when radium is brought near it, and by the rapid collapse of the leaves of a charged gold leaf electroscope under similar circumstances. But the prettiest way of observing this property of radium is as follows:—

Connect a spark gap at B, fig. 4, with an induction coil and with a vacuum tube A—a large vacuum tube gives the best result—as in the following figure. Arrange matters so that the coil gives a very steady discharge at the spark gap, and then draw back the point and plate till the discharge just passes through the vacuum tube, only an occasional spark crossing at B. Then bring the radium close to the spark gap. When

you do this the vacuum tube will go out and the discharge will not be re-established at the spark gap till you remove the radium salt.

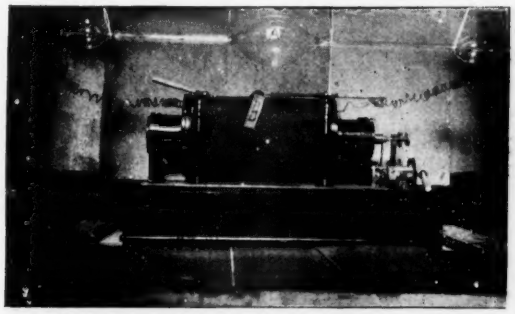


Fig. 4.

The coil must not give too strong a discharge, and the discharge must be very steady. If this is secured, the experiment can be brought off with great certainty every time.

(To be continued.)

Modern Views of Chemistry.

By H. J. H. FENTON F.R.S.

A FEW further illustrations may be given of the simple explanations which the ionic-dissociation hypothesis affords of the properties and reactions of salts in solution. Since salts are highly ionised when dissolved in even a moderate quantity of water, the properties of the solution represent the joint or added properties of the ions into which the salt has split up. The colour of the solution, for example, is that of its ions; solutions of most common cupric salts are blue and nickel salts green. This is because the acid-radicles (sulphate, nitrate, &c.) happen to give colourless ions and the colours observed are therefore due to the metallic ions. Most permanganates are pink and manganates green in solution, because the metallic ions (potassium, sodium, &c.) happen to be colourless and the colours here are due to the acidic ions. It is interesting to observe in this connection that some ions may be correctly represented by the same chemical symbol and yet show different colours and other properties in solution. Both the manganate ion and the permanganate ion are represented by the symbol MnO_4, yet one is green and the other pink. The copper ion again is blue when in the cupric state, but colourless in the cuprous state. This is explained by saying that the electric charge associated with the ion is different in the different states. A well known and simple experiment in illustration of the above views may be made as follows: Dissolve some dry cupric chloride, which is brownish yellow, in a very little water; the solution appears green. Dilute it, and it becomes blue; add a strong solution of hydrochloric acid or sodium chloride and it turns green again. Repeat the latter part of the experiment, using mercuric chloride instead of sodium chloride, and the solution remains blue. The "ionic" explanation is that the very strong solution first made contains some molecules of cupric chloride (impure yellow) mixed with copper ions (blue) and this mixture gives to the eye the appearance of green. On diluting, the cupric chloride molecules are further ionised, giving therefore less yellow and more blue. If, however, a strong solution of a metallic chloride is added, its chlorine ions, being in great concentration, prevent the further ionisation of the cupric chloride, according to well known principles which will be discussed later. It happens, however, that mercuric chloride is an exceptional salt in that it is only very slightly ionised when it is dissolved in water; there are scarcely any free chlorine ions in its solution therefore, and it can have little influence in checking or reversing the ionisation of the cupric chloride.

The colour-changes of the indicators which are used in analysis, such as litmus, may be explained in a similar way. We may regard these indicators as behaving like very weak acids and the colours they show in acid solutions, where they are very little, if at all, ionised, is the colour of the compound or molecule—red in the case of litmus. But now on adding an alkali a salt is formed, and this, like nearly all salts, is highly ionised in solution, so that we now see the colour of the acidic ion—blue in the case of litmus. The colour-changes of other well-known indicators can be similarly explained; in phenol phthalein the molecule is colourless, the acidic ion pink, whereas in the case of methyl-orange the molecule is pink and the acidic ion yellow.

[This very simple and attractive explanation of the colour-changes in indicators has, it must be confessed, received rather a severe "shaking" owing to certain recent observations, and it is probable that the effects depend rather upon changes of constitution in the indicator.]

Not only the colour but the reactions of a solution of a salt are considered to be due to its ions; a solution of ferrous, or ferric chloride, for example, gives a precipitate with alkalis due to the iron ion and a precipitate with silver nitrate due to the chlorine ion. Potassium ferrocyanide, however, gives no precipitate with alkalis, although it contains iron, and chloral gives no precipitate with silver nitrate although it contains chlorine. The potassium ferrocyanide contains its iron associated with cyanogen as a complex group, and when dissolved gives potassium ions and ferrocyanide (FeC_6N_6) ions; none of the iron, as such being present in the ionic state. Chloral again gives a solution which contains no chlorine ions; the chlorine is combined with the other elements as an undissociated molecule.

Mercuric cyanide has long been known as abnormal in its behaviour, since it answers scarcely any of the usual tests either for mercury or for a cyanide. It can be shown in various ways, however, that the salt is practically dissolved unchanged; its solution contains neither mercury ions nor cyanide ions. The poisonous character both of mercury salts and of cyanides is assumed to be due to their ions; therefore we should expect mercuric cyanide to be non-poisonous. This is stated to be the case, although it does not appear that any ardent supporter of the "ionic" theory has had the strength of mind to try its effects upon himself.

The most "chemically active" substances then in solution are those which are most ionised. It does not follow, however, that all chemical changes which may take place in solution are necessarily ionic changes. It has been shown, for example, that certain salts and acids undergo immediate double decomposition when dissolved in solvents in which no ionisation occurs.

The action of a strong acid upon the salt of a weak acid was formerly looked upon, as indicated above, as

due to the strong acid appropriating the base and turning the weaker acid out. For example—

Sodium acetate + hydrochloric acid = sodium chloride + acetic acid.

But the ionic view is quite different. Here we assume that sodium ions + hydrogen ions + chlorine ions + acetic ions give sodium ions + chlorine ions + slightly ionised acetic acid, the change consisting in the union of hydrogen ions with acetic ions, the others remaining unchanged.

It is well known that many salts which are "normal" in the chemical sense yet give an acid or an alkaline reaction when dissolved in water. Thus sodium borate or sulphite shows an alkaline reaction, whereas aluminium sulphate or ferric chloride react acid. This may be explained by assuming that the salt is partly hydrolysed by water in the first instance, giving acid and base in equivalent quantities. But if the base is strong and the acid is weak the former will be largely, and the latter slightly, ionised; so that the solution will contain an excess of hydroxyl over hydrogen ions, and will therefore react alkaline. If the base is weak and the acid strong, there will, for similar reasons, be an excess of hydrogen over hydroxyl ions, and the solution will be "acid."

Many of the ordinary chemical changes may be represented as consisting in an exchange of electric charges between the ions, or in the assumption of charges by neutral substances whereby they become ionic, and a corresponding loss of charges by the ions whereby they become "ordinary" or neutral substances. When dilute hydrochloric acid acts on zinc, for example, the metal passes into the ionic state, assuming positive charges; whilst the ionic hydrogen gives up its positive charges, becoming ordinary hydrogen gas, the chlorine remaining in the ionic state throughout. When stannous chloride is converted in stannic chloride, in solution, by chlorine, the change may be regarded as consisting in the assumption of two additional positive charges by the tin ion and the assumption of two equal and opposite negative charges by two atoms of neutral chlorine, which thereby becomes ionic. In this action the tin is said to change its valency from two to four (*i.e.*, from the stannous to stannic form), the valency, in fact, being in this sense measured by the number of unit charges with which the atom is associated when in the ionic condition.

The late Mr. H. C. FYFE.

IT is with the deepest regret that we have to record the death of one of our contributors, Mr. Herbert Fyfe. Mr. Fyfe was only thirty years of age, and his death, though not entirely unexpected, was none the less sudden. He leaves a gap in scientific journalism that none can fill as well as he. Possessed of extraordinary industry and energy, and gifted with a quite unusual capacity for assimilating the main details of the matter in hand, he wrote articles on many subjects besides the one which was his chief interest—"Submarine Warfare"—and his work never missed its mark. The loss to scientific journalism is great; but the loss to his wide circle of friends is irreparable. One of the kindest and most generous of men, one of the most helpful of colleagues, he leaves behind him a memory not alone of goodness of heart or soundness of mental fibre, but of a moral nature that was a great example of courage and sweetness.

Modern Cosmogonies.

VIII.—Protyle: What is it?

By MISS AGNES CLERKE (*Hon. Mem.*), F.R.A.S.

THE notion of a primordial form of matter meets us at every stage of cosmogonical speculation. It is the outcome of an instinctive persuasion that, if we could only "lift the painted veil" of phenomena, the real business of the universe would be found to be proceeding in the background, on a settled plan, "without haste or rest;" that uniformity is fundamental, diversity only incidental; and that the transformations of the one simplified substance might be represented by a single formula, the discovery of which would place in our hands the master-key to the locked secrets of the universe. Among untutored thinkers, some familiar kind of matter, idealised and generalised, commonly stood for the typical world—stuff. Water was the first favourite. Thales, the "wise man" of Miletus, procured his Cosmos by precipitation from an aqueous solution, and many savage tribes have devised analogous expedients. Anaximenes preferred air for the universal solvent; Heracleitus substituted fire, and set on foot a scheme of what is now often designated "elemental evolution." From the perpetual "flux of things," he conceived that the four substances selected by Empedocles as the bases of Nature were not exempt; and a fragment of his scheme survived in Francis Bacon's admission of the mutual convertibility of air and water. In the main, however, the author of the "Novum Organum" adhered to the Paracelsian doctrine of an elemental triad,* while rejecting the saline principle, and retaining, as the material substratum, sulphur and mercury.†

These twilight fancies faded in the growing light of chemical science; yet the mental need that they had temporarily appeased survived, and had somehow to be satisfied. An "Ur-Stoff" was still in demand; but the nineteenth century characteristically attempted to supply it by weight and measure. Dalton's combining equivalents afforded the warrant for Prout's hydrogen hypothesis. The problem to be faced was to find a unit-atom by the varied combinations of which all the rest of the chemical atoms might be formed. The condition indispensable to be fulfilled was that their weights should be exact multiples of that of the unit, and it came near to fulfilment by the hydrogen-atom or semi-atom. It was, nevertheless, a case in which approximate agreement was of no avail; the adverse decision of the balance finally became unmistakable; and Prout discreetly fell back, in 1831,‡ upon the resource of deriving hydrogen itself "from some body lower in the scale." His hypothesis, in short, dissolved into a conjecture. It had only emphasised the stipulation that the "Protyle" of the ancients must be such as would likewise serve for the unification of all the chemical species.

Meanwhile, the theoretical search for it had been carried on in widely different fields of inquiry. Laplace's speculations, Herschel's observations, had led to the conception of some kind of "fire-mist" as the genuine star-plasm. But its nature and properties remained indefinite, or were assigned at the arbitrary choice of adventurous

* First introduced by Basilius Valentinus. See Fowler's *Novum Organum*, p. 576, note.

† Thus recurring, as Mr. Fowler remarks (loc. cit.), to Geber's earlier view.

‡ *Dict. of National Biography*, V 1 XLVI., p 426.

cosmogonists. So the "shining fluid" of space was "everything by turns and nothing long," until Sir William Huggins, in 1864, gave it spectroscopic individuality. The "recognition-mark" of nebulium is a vivid green ray, by the emission of which it is known to have a concrete existence. Yet the little that has besides been learned about it discountenances its identification with the *materia informis* of antique philosophy. This we should expect to be the subtlest of all substances. Professor Campbell, however, has gathered indications that nebulium is denser than hydrogen. Its luminosity, at least, which is invariably associated with that of hydrogen, extends further in the same formations; it seeks a lower level. The nebulium-atom is not, then, the chemical or the cosmical unit.

This evasive entity, or something that curiously simulates it, has proved to be of less recondite origin. Sir William Crookes is amply justified in claiming the venerable designation of Protyle for the "radiant matter" first produced in his vacuum-tubes nearly thirty years ago. The discovery was astonishing and unsought; and its significance has not yet been measured. Matter assumes the "fourth state," in which it is neither solid, liquid, nor gaseous,* under the compulsion of an electric discharge in high vacua. At an exhaustion of about one-millionth of an atmosphere, the manner of its transit abruptly alters. Conduction gives way to convection. Luminous effects are abolished. The tubes cease to glow with brilliant, parti-coloured striæ; the poles are no longer marked by shimmering halos or brushes; only a green phosphorescence is seen where the glass walls of the receptacle are struck by the stream of projected particles. They come, with half the velocity of light, exclusively from the negative pole, the positive pole remaining inert. Hence the name "cathode-rays," bestowed by Goldstein on the carriers of electricity in highly-exhausted bulbs.

These mysterious, sub-sensible agents possess certain very definite properties. Their paths are deflected in a magnetic field; they can traverse metallic films; and their investigation in the open, thereby rendered feasible, has shown them to possess photographic efficacy, and the faculty of breaking down electrical insulation; moreover, they transport a negative charge of fixed amount, and have a determinate momentum. They are then assuredly no mere pulsations of the ether; unless our senses "both fail and deceive us," their quality is material. Material, yet not quite with the ordinary connotation of the term. The most essential circumstance about the cathode-rays is that they remain unmodified by the chemical diversities of the originating gases.† A hydrogen tube yields identically the same radiant matter as an oxygen or a nitrogen tube. Here then at last we have within our grasp undifferentiated substance—matter not yet specialised, neither molecular nor atomic, matter destitute of affinities, exempt from the laws of combination—matter in its inchoate, and perhaps ultimate, form; in a word, the far-sought Protyle.

Already, in 1879, Sir William Crookes conjectured the infinitesimal missiles propelled from the cathode to be the "foundation-stones of which atoms are composed." ‡ And in 1886 he pronounced them more decisively to be the raw material of atoms, which, to Sir John Herschel's apprehension, bore the unmistakable stamp of a "manufactured article." Nor did his recent commentator refrain from attempting distantly to divine the method of their construction, or from laying his finger on the by-products and residues associated with it,*, although he felt compelled to relegate the cosmic factory to the edge of the world, where inconceivable things may happen. All this, indeed, seemed, in the late Victorian era, like mounting the horse of Astolfo for a trip to the moon; and sane common-sense pronounced it fantastic enough to "make Democritus weep and Heracleitus laugh."† But we have since learned from Nature herself some tolerance of audacities.

Step by step, the new order of ideas has irresistibly come to the front. It owed its origin to Sir William Crookes's skill in producing high vacua, and the consequent development in his tubes of radiant effects. Then, in 1879, universal importance was claimed for them, and matter in the "fourth state," by a revival of the dreams of the ancients, expanded into a kind of visionary Protyle. Philipp Lenard made the next advance towards its actualisation by slipping it, in 1894, through an aluminium window, and watching its behaviour towards ordinary matter. Two years later, Röntgen-rays made their entry on the scene; and before the end of 1896, Becquerel, hurrying along the track of novelties, came upon the momentous discovery of radio-activity.

A revision of ideas has ensued. Some time-honoured assumptions have had to be discarded; so-called laws have been found to need qualification; the old system of physics is consequently out of gear, and much time and patient labour must be expended upon the adjustment of the new and improved system destined to replace it. The leading and indisputable fact of the actual situation is that a number of hitherto unsuspected modes of energy have been disclosed as widely operative in Nature. All are of a "radiant" character. They travel in straight lines with enormous speed; they start from a material base, and produce their several effects on reaching a material goal. Now these effects are closely analogous, notwithstanding that the rays themselves are radically dissimilar. Those of the cathodic kind are corpuscular. They consist of streaming particles, each, according to Professor J. J. Thomson, of about one-thousandth the mass of the hydrogen-atom. Others—the noted "alpha rays"—are atomic; they are supposed to aggregate into helium. Finally, the Röntgen variety are ethereal; they are composed of light-vibrations reduced in scale, and augmented correspondingly in frequency. What is most remarkable is that these various forms of activity give rise, by different means, to very much the same results. They are, in fact, distinguishable only by careful observation. They possess in common, though not to the same degree, the faculties of penetrating opaque matter, of impressing sensitive plates, of evoking fluorescence; while under the impact of cathode and Röntgen rays, as well as of ultra-violet light, insulated electric charges leak away and evanesce. There is, however, one clear note of separation between cathodic and X-rays in the sensibility of the former, and the indifference of the latter, to magnetic influence. Thus alone, it would appear, is electrified matter set apart from what we call ether. If flying corpuscles could be obtained in a neutral condition, the distinction would vanish. But this is evidently impracticable. Indeed, advanced physicists abolish the material substratum of the corpuscle, and assign its attributes to the associated atom of electricity. It is, at any

* Crookes, *Phil. Trans.* Vol. CLXX., p. 163.

† J. J. Thomson, *The Discharge of Electricity through Gases*, p. 195; *Phil. Mag.* Vol. XLIV., p. 311.

‡ *Science*, June 26, 1903.

* *Proc. Chem. Society*, March 28, 1888.

† *Times*, March 30, 1888.

rate, undeniable that the electrical relations of matter become more intimate as our analysis of its constitution goes deeper. Ether, electricity, matter, all seem to merge together in the limit; their distinctions ultimately evade definition. So animal and vegetable life appear to coalesce in their incipient stages, and develop their inherent differences with advance towards a higher perfection.

The various branches of inorganic nature, too, possibly spring from a common stock. Our powers of discrimination fail to separate them as we trace themdownward; but that may be because of the inadequacy ofthe guiding principles at our command. A larger synthesis is demanded for the harmonising of multitudinous facts, at present grouped incongruously, or left in baffling isolation, and it is rendered increasingly difficult of attainment by the continual growth of specialisation. Year by year details accumulate, and the strain of keeping them under mental command becomes heavier; yet what *can* be known *must*, in its essentials, be known as a preliminary to extending the reign of recognised law in Nature.

Sooner or later, however, the wealth of novel experience recently acquired will doubtless be turned to the fullest account. Just now, we can grasp only tentatively its far-reaching implications. They have a very important bearing on the hoary problem of the genesis of visible things. The questions of what matter is, and of how it came to be, have been cleared of some of the metaphysical cobwebs involving them *ab antiquo*, and insistently crave definite treatment by exact methods. We should, indeed, vainly aspire to reach—or to comprehend, even if we could reach—an absolute beginning. To quote Clerk Maxwell's words: "Science,"* he wrote, "is incompetent to reason upon the creation of matter itself out of nothing. We have reached the utmost limit of our thinking faculties when we have admitted that, because matter cannot be eternal and self-existent it must have been created." The discovery that atoms disintegrate into corpuscles does not then bring us any nearer to the heart of the mystery; but it is eminently suggestive as regards secondary processes.

Acquaintance with ultra-atomic matter, begun within the narrow precincts of "Crookes' tubes," has advanced rapidly since "radiology" took its place among the sciences. For, from the time when Becquerel first saw a plate darkened by the photogenic projectiles of uranium, and Madame Curie sifted radium from the refuse of the mines of Joachimsthal, the lines of proof steadily converged towards the conclusion that chemical atoms are not only divisible, but that their decay progresses spontaneously, irresistibly, in fire, air, earth, and water, as part of the regular economy of Nature. To explain further. Radio-active bodies are composed—according to Rutherford's plausible hypothesis—of atoms in unstable equilibrium. The gradual changes incidental to their own internal activities suffice to bring about their disruption. And their explosive character is obviously connected with their unwieldy size, since uranium, thorium, and radium, the three substances pre-eminent for radio-activity, possess the highest atomic weights known to chemistry. The precarious balance, then, of each of these complex, though infinitesimally small, systems is successively overthrown, regardless of external conditions or environment, their constituent parts being hurled abroad with the evolution of an almost incredible amount of energy. Their products include cathode-rays; matter in the "fourth state," matter a thousand times finer than hydrogen, is ejected in torrents from the self-pulverised atoms of radium. Moreover, the issuing rays are equivalent to currents of negative electricity. Each corpuscle bears with it an electron, or is itself an electron; for the choice between the alternatives is open. In either case, we are confronted with matter apparently in its ultimate form; and to that form ordinary, substantial bodies tend to become reduced. Electrons may fairly be called ubiquitous. They occur in flames, near all very hot masses, wherever ultra-violet light impinges on a metallic surface*; they are freely generated by Röntgen and cathode rays; they are the agents of electrical transmission in conductors. Everywhere throughout the universe, then, atoms are in course of degradation into corpuscles. But no information is at hand as to the scene or mode of their reconstitution. The waste and decay are patent; the processes of compensation remain buried in obscurity. Indeed, Sir William Crookes anticipates the complete submergence, at some indefinitely remote epoch, of material substance in Protyle, the "formless mist" of chaos. He assumes an identity between the past state and the future, leaving, however, the present unexplained. The break-up of matter, in fact, does not render its construction the more intelligible. Running-down is an operation of a different order from winding-up. It is an expenditure of a reserve of force. It needs no effort; it accomplishes itself. But to create the reserve for expenditure demands foresight and deliberate exertion; it implies a designed application of power. Now each atom is a store-house of energy representing the force primitively applied to reduce some thousands of free electrons to the bondage of a harmoniously working system. Its disruption is accompanied by the dissipation of the energy previously accumulated in it; and that atomic systems are not calculated for indefinite endurance is one of the most surprising of modern discoveries. The secret of their original construction is, nevertheless, still impenetrable. That they are composed of Protyle—that their clustering members are corpuscles moving under strong mechanical control—is more than probable. And the law of order adumbrated by what are called the "periodic" relations of the chemical elements shows that their concourse was very far from being fortuitous. But beyond this point, there is no holding-ground for definite thought. We are ignorant, too, whether the process of building matter out of Protyle is at present going on, or was completed once for all in the abysmal fore-time, decay being now definitive. Nor is it likely that we shall ever succeed in capturing with recognition a brand-new atom freshly minted for cosmical circulation.

* *Ency. Brit.*, art. *Atom*.

* Fleming, *Proc. Royal Institute*, Vol. XVII., p. 169.

A FREE Public Reference Library, having distinctive characteristics, is in course of formation by the London County Council at the Horniman Museum, Forest Hill. The primary intention is to encourage the study of Geology and the biological sciences (Botany, Zoology, and Anthropology)—especially as represented in the Horniman Museum collections—by providing the best books on these subjects, more particularly the works of admitted authority which, by reason of cost and a relatively small demand, are not ordinarily found in libraries freely accessible to the general public. Although undue importance is not attached to merely descriptive works, a distinctive feature of the library is the prominence given to the special books necessary to a detailed study of any section of the Archæology or the Natural History of the British Islands. Text-books, manuals, and monographs are supplemented by works on the theoretical aspects of every branch of science with which the library is concerned, and books designed to stimulate individual observation and inquiry, including the most recent manuals, British and American, of "nature-study," are liberally provided.

XUM

Animated Photographs of Plants.

By Mrs. DUKINFIELD H. SCOTT.

THE kinematograph has now been in use for many years for successfully reproducing rapid movements of living objects, such as the boat-race, an express train in motion, or the Coronation procession. Its use for showing, at an accelerated speed, *slow* movements which cannot be watched by the eye, and which last over a considerable period of time has, no doubt, often been thought of, but has not been put to much practical test. In fact I know that some years ago, two eminent professors of science visited one of the popular places of entertainment to watch a boxing match on the screen, with a view to obtaining hints for the use of the kinematograph for scientific purposes. I did not hear that the experiment went any further.

In the plant world there are many fascinating subjects possible. If photographs of a germinating seed are taken by the kinematograph at regular intervals during many days until the seed has germinated and sent up its seed leaves, the photographs can be thrown on the screen and the spectators can have the pleasure of seeing the earth raised up by the swelling seed, the seed-coat thrown off, the seed-leaves emerge, straighten themselves out, and then the first leaves burst forth.

If the plant is a climbing one such as the French Bean, another plate will show the point of the stem swaying round in large circles till it comes into contact with its support, and twines round and round the stick provided for it. Professor Pfeffer, of Leipzig, in 1900, devised a very perfect apparatus of this sort for class demonstration, the photographs being taken by electric light with a film kinematograph. But the expense of this apparatus is too great for the use of amateurs, as, exclusive of the initial expenditure, each new film costs 90 marks = £4 10s. I hope to explain in the following pages the method of working a smaller and less expensive apparatus, which is within the reach of the ordinary amateur photographer.

The first plant selected for experiment was *Sparmannia africana*,* a native of South Africa well known in our greenhouses. A photograph is given of the inflorescence of this plant (fig. 11), which gives some idea of its general appearance. It is a plant which belongs to the same order as the Lime Tree, and has many attractive features;

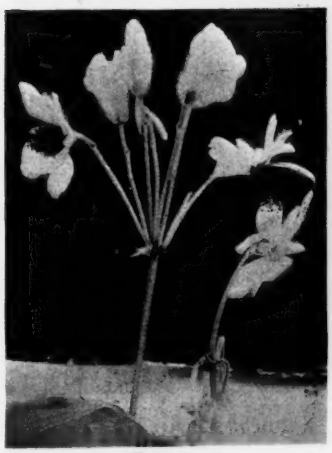


Fig. 11.

Sparmannia africana.

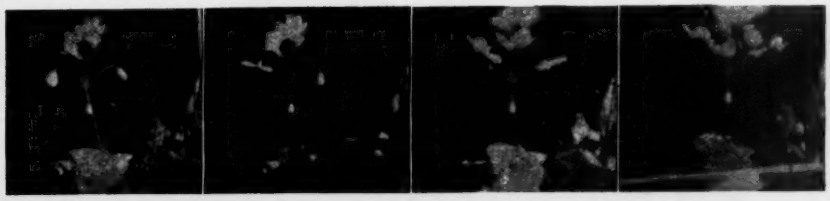


Fig. 12. Fig. 13. Fig. 14. Fig. 15.

Fig. 11 shows the general appearance of the inflorescence, taken at 5 a.m. Flowers just opening from the right position.

Fig. 12.—Photograph 10 shows bud on the left swelling.

Fig. 13.—Photograph 80. The bud is half open, and the bud on the right is in the vertical position, ready for opening.

Fig. 14.—Photograph 150. Both flowers open.

Fig. 15.—Photograph 220. Still further open.

* Annals of Botany, Vol. XVII., No. LXVIII. Sept, 1903.

Sparmannia africana.

Figs. 1-10. Shows stages selected from the Kammatograph photographs in the opening of a bud.

Fig. 1.—Watch the bud. Fig. 2. Fig 3. Fig. 4. Fig. 5.

Fig. 6. Fig. 7. Fig. 8. Fig. 9. Fig. 10.

the buds, which hang down round the stem, only open in sunlight at a temperature of not less than about 60° F. 26° C., the flowers shut up every night at varying times according to their age, opening again each morning for several days, and each day the flower alters in appearance. This can be seen in the drawing—the buds are hanging round the stem—one flower is just opening; there are two older flowers and several in an upright position which have closed, and are about to form fruits. Then the stamens are sensitive, and when touched move away from the stigma. The way the flowers are arranged on the stem is also interesting; the buds hang down at first, then move upwards during the night, and then bend again into the vertical position before opening as in fig. 1 bud. There is a little joint or pulvinus on each flower stalk where the bend takes place; when the fruit is ripe a layer of cork is formed at this joint and there the fruit is detached. This plant seemed, therefore, a very suitable one for experiment. I aimed at photographing the inflorescence at intervals while young, so as not only to show the opening of the flowers, their closing at night, and the movements of the stamens, but also the development of the inflorescence from bud to fruit. I hoped in this way to show the progress of the plant during several months in a few minutes on the screen.

My first experiments with a film kinematograph, though successful enough to encourage me to proceed, had many defects; the machine was not constructed for this sort of work, and the maker was unable to help in adapting it. The celluloid film would not stand the constant damp of the greenhouse, and this was only one of the many difficulties encountered with this machine. My most successful experiments have been with the Kammatograph, in which the photographs are taken on a glass disc instead of a film. The disc, 12 inches in diameter (half of one is shown in fig. 16) is suspended in a metal ring; it is coated with a sensitive emulsion, just like any ordinary photographic plate, from which it only differs in size. It is capable of taking 350 photographs. When ready for use, the disc is put into the machine, which is light proof, and by means of a handle at the side can be rotated, so that every part of the plate is exposed before the small oblong opening in front of the lens and the photographs appear in a spiral on the disc. In ordinary kinematograph work, the handle is rotated at a uniform speed and a series of snapshots are produced, but for the work now required, it is necessary to take time exposures, as photographs must be taken at all times of the day and in all weathers; a large number of photographs are only wanted when rapid movements, such as that made by the stamens when touched or when a bud is opening, are taking place.

For many parts of the day a photograph taken once every quarter of an hour is sufficient.

The practical difficulties in this kind of photography are rather overwhelming at first, but I have now overcome the principal ones, and think that anyone who cares to try the experiment for himself will find it fairly easy. The expense of each negative plate is 2s. 6d. and the positive is also 2s. 6d., so that the total cost of each completed kinematograph picture is 5s., plus the expense of developing. If this is done professionally, each plate costs 1s. to develop, thus bringing the cost up to 7s. The developing and printing are extremely simple compared with a film negative, as all the 350 photographs are developed and printed at the same time and in the same way as an ordinary plate; this seems to me a great practical advantage.

Two principal points must be considered:—

1.—The apparatus must be quite rigid, as the slightest movement would spoil the whole result. Mr. Kamm has now devised a very satisfactory stand for this purpose.

2.—Each photograph must be exposed uniformly, and, as they have to be taken at all times of day and night, this at first was one of the greatest difficulties. By the use of Wynne's actinometer, this difficulty was completely

Weather Plant (*Abrus precatorius*).

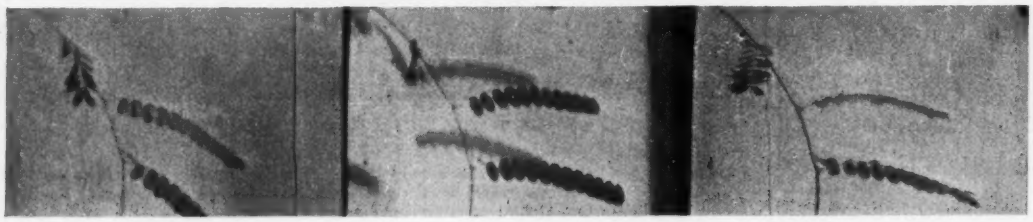


Fig. 22. Fig. 23. Fig. 24.

Fig. 22.—Photograph. Position of leaves at 2.18 p.m., on March 31, 1904.

Fig. 23.—Photograph. Position of leaves at 5.15 a.m., the whole rachis is moving up, though the leaves are not yet open.

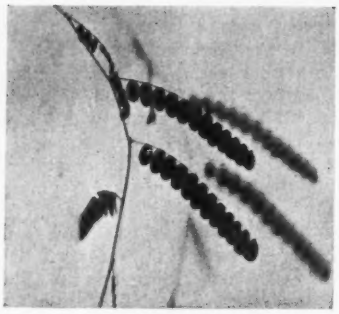


Fig. 25.

Fig. 24.—Photograph. Position of leaves at 10 a.m., April 1, 1904.

Fig. 25.—Shows the night position.

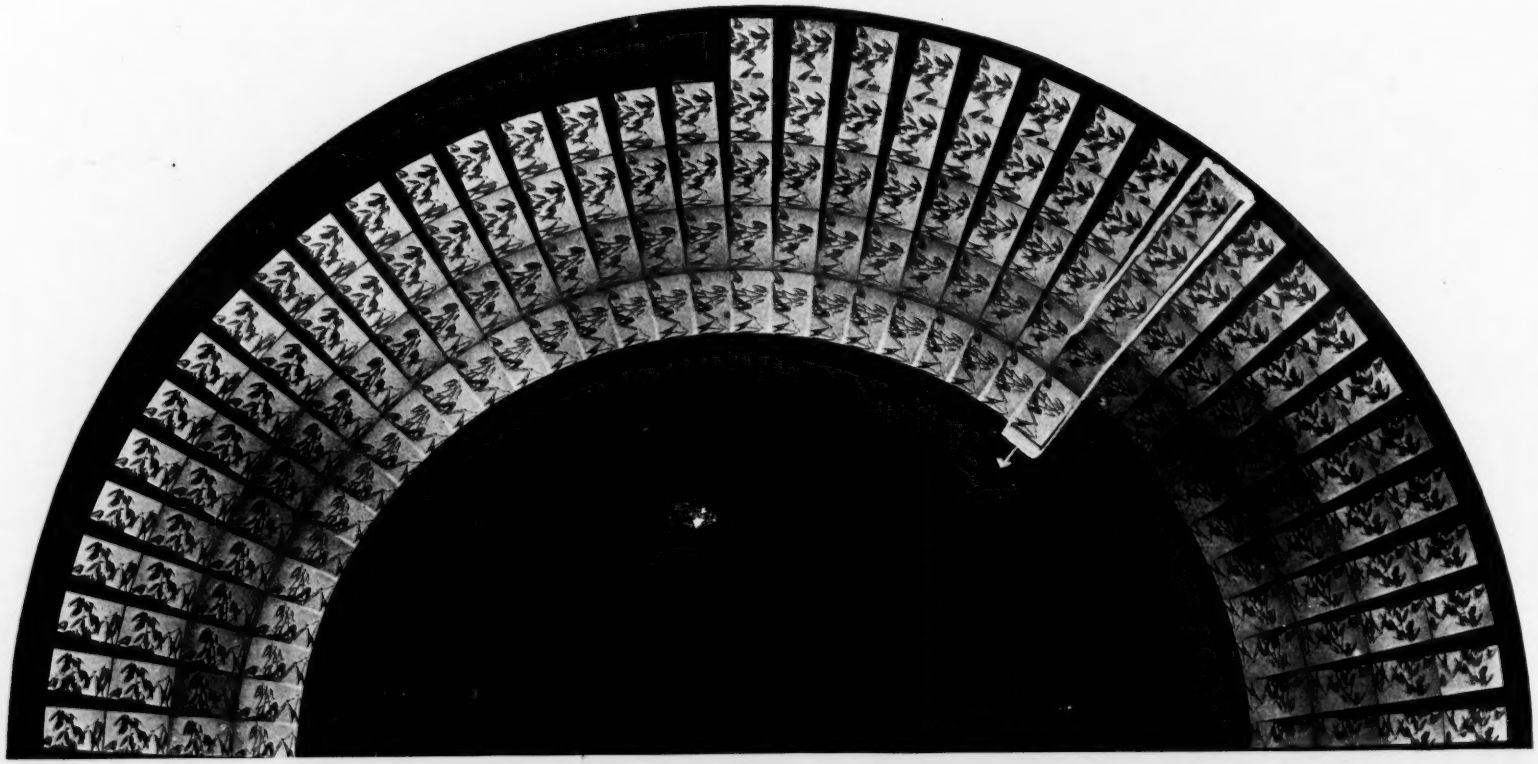


Fig. 16.

SENSITIVE PLANT. *Mimosa sensitwa.*

Fig. 17. Fig. 18. Fig. 19. Fig. 20. Fig. 21.

Fig. 17. Photograph. Shows the leaflets open, just after the match has been applied to the tip of a leaf.
Figs. 18, 19, 20. Photographs. All stages in the closing of the leaflets.
Fig. 21. Photograph. Shows the plant with the leaves almost closed.
In Fig. 16. These photographs are enclosed between white lines.

removed. I at first used magnesium ribbon for the night exposures; but this was very laborious work. I now use an incandescent lamp fed by methylated spirits, but for those who are fortunate enough to have electricity an arc lamp is best of all. When once the right exposure is found all further difficulty in this direction is removed. No doubt the ideal method would be to have a clockwork apparatus for turning the machine which at the same time turned on the light and exposed the plate, as Professor Pfeffer has.

The Sensitive Plant.—*Mimosa sensitiva.*

This plant closes its leaves when touched, and also naturally shuts them up at night. The leaf is divided into two *pinnæ*, each division bearing numerous leaflets. The best way to make them work is to light a match and put it under the end pair of leaflets at the tip of one of the *pinnæ* of the leaf. The first pair of leaflets then shut, then the second, and so on till the whole *pinna* is closed; the same stimulus then closes the two leaflets next the stalk of the neighbouring *pinna*, and the leaflets close one after the other till the tip of the leaf is reached. Every leaf on the same branch follows suit. After some time the leaf-stalk falls, another leaf closes in the same way, until the effect of the stimulus is at an end. These photographs are taken as quickly as possible consistent with giving the right exposure, and require a whole plate.

A second plate shows the leaves reopening, taken at intervals of about five minutes; the exposures were continued until the leaves shut into the sleep position for the night.

The more common species, *M. pudica*, serve equally well for experiment.

The Weather Plant.—*Abrus precatorius.*

There has been much discussion about this plant lately as to whether it really predicts the weather to be expected in the future. I have a series of photographs extending over one complete day, which show the regular day and night movements of the plant. The plant was kept in a glass case sheltered from wind and sun at a temperature not below 73° F. = 22·5° C. The plant was placed with the rachis (midrib) of its youngest leaf facing north. The photograph was begun at 11.30 a.m. on Thursday, March 31, 1904, and continued until 10.30 p.m. It takes up the sleep position at 4.30 p.m. Then the photograph was begun again at 5 a.m. on April 1, while the leaves were still shut. As the sun rises the leaflets gradually open, and each leaf raises itself so quickly that one can watch the movements easily.

The kinematograph seems to afford a means of definitely settling this question. The photographs give an unbiassed record of the movements of the plant and the weather reports, barometrical and thermometrical readings, records of earthquakes, &c., can be provided by the various meteorological stations, so that if a re-investigation is ever considered necessary after Professor Oliver's* exhaustive report on the subject the data could in this way be obtained.

Climbing Plant (*Mucuna nivea*).

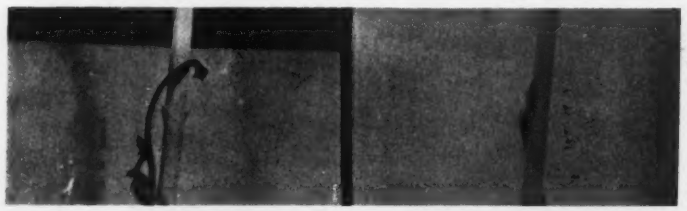


Fig. 27. Fig 29.

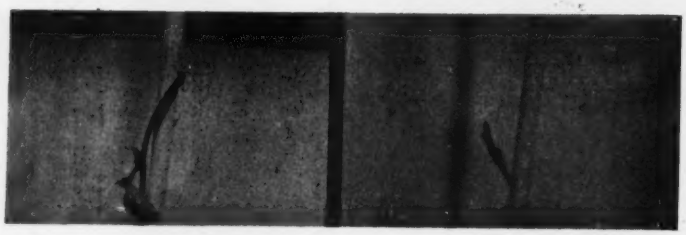


Fig. 26. Fig. 28.

Figs. 26 and 27.—Photographs. Show the tip of the stem turning round the support.
Fig. 28.—Photograph. Shows the same tip appearing on the other side of the support.
Fig. 29.—Photograph. Shows the tip applied closely to the support.

Climbing Plants.—This is a very fascinating subject for the Kammatograph. One has to focus the support on which the plant is climbing and to keep the tip of the climbing stem in the field. As the plant grows in length the Kammatograph has to be raised. In showing the photograph with the lantern a jerk will be noticed every time this is done, so if it can be arranged to alter the stand every morning one can see how much the plant has twined each day. Anyone who takes the trouble to photograph a climbing plant will be surprised at the very curious movements of the tip. The way in which it circumnutates, turning to every point of the compass, then gives a twist when it comes into contact with its support, is very fascinating.

The real difficulty with the climbing plant is that it grows and climbs just as much at night as it does in the day, so that if it is not photographed at night there is an interruption when projecting it with the lantern corresponding to the beginning of each new day. I am afraid a perfect photograph of a climbing stem will not be attained without clockwork apparatus, as the trouble involved of sitting up all night for at least a week would be too much to expect, even of the most ardent photographer.

The plant illustrated is a Calcutta stem-climber, *Mucuna nivea.* It was photographed for a week from 6.30 a.m. to 11.30 p.m.

I hope in these few pages that I may have succeeded in interesting some of the readers of "KNOWLEDGE" in the work of making animated pictures of plants, and shall be only too glad if I can be of any use to anyone who wishes to try these experiments. The illustrations of such a subject are naturally disappointing, as they cannot appear animated, but if anyone will take the trouble to cut out the ten figures of the opening bud of *Sparmannia africana* (Figs. 1-10) and paste each on a card or luggage label, and fasten them together closely at the lower end, by letting each figure pass before the eye they will appear animated and will give some rough idea of what the plate will show when projected with a lantern.

* Kew Bulletin, Jan., 1890.

The "Canals" of Mars.

A Reply to Mr. Story.

By E. WALTER MAUNDER, F.R.A.S.

SEVERAL correspondents having expressed a strong wish that I should give some reply to Mr. Story's letter on this subject, I will endeavour to do so; not without reluctance, as the line which Mr. Story took seemed, in my opinion, hardly likely to advance our knowledge.

If I may briefly summarise Mr. Story's objections to the paper communicated by Mr. Evans and myself to the Royal Astronomical Society last June, they come under three heads. He objects to me as the author, to the methods employed, and to the deductions drawn.

The first objection is of course a somewhat delicate one for me to handle. It deals rather with the personal than with the scientific, and I have no inclination to fill the columns of KNOWLEDGE with detailed evidence of my claim to be considered an "expert" on the subject of Mars. Let it suffice that as long ago as 1877, I had made a thorough study of the planet, using the fine 12¾-inch Merz refractor of Greenwich Observatory. In 1892 and 1894 I also used the 28-inch Grubb refractor—certainly one of the most perfect objectives in existence. I give two or three examples of my earlier drawings, from

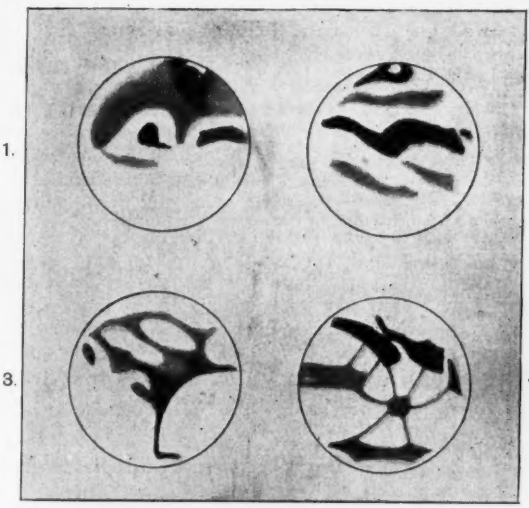


Fig. 1.—Drawings of Mars made with the 12¾-inch Refractor of the Royal Observatory, Greenwich.

			H.	M.				H.	M.
1.	1877	September 29th	10	10	2.	1877	September 24th	11	43
3.	1879	November 5th..	13	5	4.	1882	January 9th ..	12	2

which it will be seen that I had recorded some of the markings now familiar to us as "canals" and "oases," even before Schiaparelli had published his results, and quite a number before they had been generally recognised by observers.

So much for the person, next for the methods. Mr. Lowell and Mr. Story both appear to object to the employment of terrestrial experiments to elucidate planetary appearances. Mr. Lowell's opinion to this effect may be found in his letter published in the "Observatory" for January, 1904, p. 49: "Permit me, in conclusion, to point out to you . . . that the only evidence germane to the matter is to be got from astronomical observations directed to that end." But as Mr. Story points out, Mr. Lowell himself has set on foot terrestrial experiments for the express purpose of drawing inferences with respect to his observations of Mars, and Mr. Story approves of his so doing. Eliminating what is common to the two cases, the one of which meets with Mr. Story's approval, and the other with his disapproval, the only residuals are Mr. Lowell on the one hand and myself on the other, and the statement is reduced to the simple proposition that he approves of Mr. Lowell and disapproves of me, irrespective of our actions. In other words, his second objection is but a more diffuse way of restating his first.

But to take the matter seriously, let us see precisely what is the point where Mr. Lowell's views and my own diverge. It is not in the chief markings of Mars. Mr. Lowell sees and draws these substantially as I saw and drew them in 1877, and as Beer and Mädler drew them in 1830. It is not in respect to the appearance of the "canals"; I observed and drew "canals" as far back as 1877, and though of course Mr. Lowell has seen and drawn far more "canals" than I have, those that I saw were substantially of the same character as his; and in the discussion of this question I have been most careful, both in writing and speaking, always to point out that I was not throwing doubt either on the fidelity or the skill of any of the observers of Mars. Mr. Evans and myself wrote: "It would not be in the least correct to say that the numerous observers who have drawn 'canals' on Mars during the last twenty-five years, have drawn what they did not see. On the contrary, they have drawn, and drawn truthfully, that which they saw." ("Monthly Notices" Vol. LXIII., p. 499.) Nor have I ever asserted or assumed "that the canals are seen as very faint lines, so faint that their existence is doubtful even to experienced observers." I know the reverse by actual experience.

We agree on a third point. Mr. Lowell is absolutely convinced, and in this I am quite at one with him, that it is not possible that an actual network so geometrical as that which he represents can be the result of purely physical causes. Mr. Story has no doubt seen the very fascinating book which Mr. Lowell published on "Mars" in November, 1895, and has read the pages 148-154.

After this we differ. Mr. Lowell attributes this confessedly utterly unnatural network to the handiwork of intelligent beings who have woven over their planet these "grotesque polygons" to use Schiaparelli's expression.

This, be it noted, is inference, not observation; and an inference which demands the assumption that, were Mars brought much nearer to us, or our power of seeing greatly improved, these grotesque polygons would still persist, and would never resolve themselves under better seeing into markings which we could reasonably ascribed to the unaided processes of Nature.

My inference is different; the unnaturalness may be due to the imperfection of our seeing. I rely on well-known facts respecting the theory of vision and the structure of the eye, and the eye is our necessary instrument for observation. We have no right to resort to the unknown and the artificial, before we have exhausted

the known and natural methods of explaining a phenomenon. My inference is one based on the observed effects of known causes; Mr. Lowell's inference is an excursion into fairyland.

We know that the smallest single dark marking on a bright ground which can be seen by an observer of perfect sight, without optical assistance, must have a diameter of at least 34 seconds of arc. This diameter depends upon the size of the rods and cones of the eye which receive the visual impression, and compose the sensitive screen. It is therefore an inevitable limit. As this diameter is necessary for the object to be merely perceived, or, in other words, to create any sensation at at all, it follows that in order that the actual shape of the object may be recognised, its diameter must considerably exceed this limit, otherwise it will be seen as a truly circular dot, whatever its actual shape.

This is the case for small isolated markings just within the limit of visibility. The case is different for extremely elongated markings; the increased length of a marking will compensate for diminished breadth up to a certain limit, but not beyond it. For a line of indefinite length the limit of breadth approaches two seconds of arc. A line of a breadth below one second of arc is invisible, no matter what its length; but it must have a breadth many times this amount before it can be seen as anything else than a mere line—before irregularities in shape and breadth can make themselves apparent.

In naked-eye vision, therefore, there is a considerable range within which small objects, whatever their true shape or nature, can only be seen as dots or as lines. The result is that these two forms are certain to come in evidence whenever we are dealing with objects too minute to be fully and properly defined.

The problem becomes more complicated when we are using optical assistance, as there is a limit of definition belonging to the telescope as well as to the eye. But the principle remains the same; the result of adding the limitation of the telescope to the limitation of the eye being that the actual magnification of the telescope can never be nearly as effective as it is nominally. A power of 300 on the best telescope in existence, and under the best atmospheric conditions, would never show the features of the moon as distinctly as they would be seen if the moon were brought 300 times as near.

Mr. Story and Mr. Lowell both object that terrestrial (or, as they are more usually called, "laboratory") experiments are altogether beside the mark when applied to the interpretation of astronomical observations. The contention is a ridiculous one, and if logically applied would render it impossible to determine the instrumental errors of a transit circle by the use of meridian marks, collimators, or mercury trough, or the personal equation of an observer, except by actual stellar observation. They would also forbid us to identify the lines of solar or stellar spectra by comparison with those of any terrestrial element.

But since it is contended that Mars alone can give us valid information on the subject, to Mars let us refer. If we turn to the drawings made by Beer and Mädler in 1830, two small objects exceedingly like one another appear repeatedly. These are two dark circular spots, the one isolated, the other at the end of a gently curved line. Both recall the "oases" which figure so largely in many of Mr. Lowell's drawings, and the curved line at the termination of which one of the spots appears, is not unlike the representation which has been given of several of the "canals." There can be no doubt that in the year 1830 no better drawings of Mars had appeared than those to which I have referred, and that in representing these two spots as truly circular Beer and Mädler portrayed the planet as they best saw it. The one marking we call to-day the *Lacus Solis*, the other the *Sinus Sabæus*, and we can trace the gradual growth of our knowledge of both markings from 1830 up to the present time. The accompanying sketches of the same region

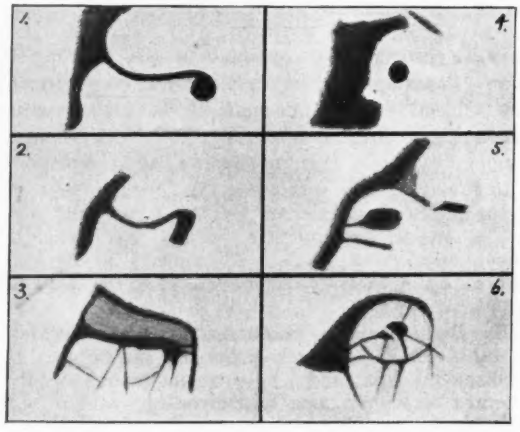


Fig. 2.—Sinus Sabæus and Lacus Solis.

1.	Sinus Sabæus.. ..	Beer and Mädler	1830.
2.	" "	Lockyer ..	1862.
3.	" "	Schiaparelli ..	1890.
4.	Lacus Solis	Beer and Mädler	1830.
5.	" "	Lockyer ..	1862.
6.	" "	Schiaparelli ..	1890.

by Lockyer, in 1862, and by Schiaparelli, in 1890, illustrate well how the character of the markings revealed themselves with increased telescopic power and experience in the observer.

"At first it seemed a little speck
And then it seemed a mist,
It moved and moved and took at last
A certain shape I wist.
A speck, a mist, a shape."

If Beer and Mädler, in 1830, had argued that the precise circularity of these two spots, as they appeared to them, was proof that they were artificial in origin, would they have been correct? Would not the answer have been valid that a spot too small to be defined must appear circular, and that, therefore, the apparent circularity probably covered detail of an altogether different form? We know that it would. Yet it is that same argument in a far stronger form against which Mr. Lowell and Mr. Story are contending to-day. Beer and Mädler only drew two of these spots; Lowell shows over sixty. Beer and Mädler's two spots seemed to them precisely alike; how utterly different those two spots appear to us to-day the diagram may serve imperfectly to indicate. Mr. Lowell's sixty or more "oases," with one or two exceptions, appear all of the same character. Will anyone dream that if the next seventy years brings telescopic development equal to that shown in the last seventy, the present uniformity of Lowell's "oases" will persist, any more than the likeness of the two spots observed by Beer and Mädler? We need not even wait for the seventy years. Up to the present moment I have carefully avoided anything like criticism of the drawings of any observer of Mars. I have repeatedly stated that I accepted them as being both faithful and skilful representations of what the observers saw. But it is necessary here to point out that the extreme simplicity of type of

both "canals" and "oases," as shown by Mr. Lowell, is not confirmed by the best observers. In the last number of "KNOWLEDGE" Mr. Denning writes (p. 67): "There are really many distinctions in the canal-like markings; some of them are quite broad and diffused shadings, while others are narrow, delicate lines." The Rev. T. E. Phillips has recently insisted strongly ("Monthly Notices," Vol. LXIV., p. 40) on the same fact, and I could increase the testimony indefinitely. There can be no doubt that the best observers not merely agree in stating that the "canals" differ very widely in their characteristics, but they also agree closely in the characteristics they assign to special "canals." With regard to Lowell's observations I can, of course, speak only with reference to those which he has published, but speaking with reference to these there can be no doubt that he fails to exhibit that wide variation in character between certain "canals" upon which these and other leading observers are fully agreed. This seems to me clear proof (so far as his published drawings go) not of superior conditions and skill on Mr. Lowell's part, but of a most marked inferiority in one respect or the other. Whether it be the location of his observatory that is at fault, or the definition of his telescope, or his own personal skill in observation, or most probable of all, in delineation, the fact remains that—despite the multiplicity of his observations and the perseverance, which cannot be too highly praised and too fully recognised, with which he has observed Mars in season and out of season—he has failed to record differences apparent to a consensus of other first-rate observers. Especially he has failed to recognise what Denning and Schiaparelli had recognised as early as 1884, that many of the "canals" were very far from being straight lines of uniform breadth and darkness, but showed evident gradations in tone, and irregularities occasioning breaks and condensations here and there. Of all the thousands of drawings of Mars which I have examined, those that most perfectly corresponded to Mr. Lowell's were the work of a young novice and were made in by no means an ideal station, using a small home-made telescope.

It is made an argument in favour of the actuality of the "canals" that they have been seen with such distinctness, or with such frequency. The argument is based upon a very complete ignorance of the appearance of the fictitious "canals" observed in the experiments made by Mr. Evans and myself. I have myself been completely taken in by a little drawing on which the Syrtis Major and Sinus Sabæus were shown. As I looked at it by far the most insistent feature was a straight, narrow, intensely black line corresponding to the Phison. Yet that astonishingly vivid impression was really due to the integration of two or three feeble lines, irregular, broken, and serpentine curves, and half a dozen utterly invisible dots. If I had looked at that drawing a thousand times, or if a thousand other observers had examined it under the same conditions as to distance, they could only have seen what I saw—a dark, straight line, as sharp as if cut by a graving tool.

The change in the distinctness of the "canals," consequent on the progress of the Martian seasons, was no discovery of Lowell's; the fact was realised by Schiaparelli very early in his observations. But so far from rendering it more probable that the "canals" indicate artificial water-ways, it affords a most serious argument against their having that character. For water cannot flow uphill, yet the water from the melting polar snow, according to Lowell, must flow upwards to reach the equator. If, with Lowell, we consider the dark markings on Mars to be vegetation rather than water, they would change in appearance with the seasons whether they were of natural origin and irregular shape, or were artificial and symmetrical; and Mr. Lowell's 8500 observations do not increase the probability of his theory more than 85 or 8½ would do. A "canal" or an "oasis," if seen only as a straight line or a circular dot, that is to say, if seen only in the simplest possible form, affords no proof that the precise form under which it appears has any actuality. It is only when the object begins to show detail that we are sure that we are beginning to see it as it is. And one of the most convincing testimonies that Mr. Evans and myself have been following the right line has been shown by the attitude which the most experienced observers of Mars have adopted towards our inquiry. They have claimed, as Mr. Denning did in last month's "KNOWLEDGE," that certain "canals" are undoubtedly real, for they have been resolved or partially resolved into minuter details, being "composed of small, irregular condensations." Others they have admitted may be "canals" only in appearance, being actually either "the edges of half-tone districts or the summation of very minute details." In both the claim and the admission they are in perfect accord with the position held by Mr. Evans and myself. On the other hand, Antoniadi, Barnard, Denning, Molesworth, Stanley Williams, have all held themselves aloof from the bizarre delineations and yet more bizarre theories which Lowell has promulgated. Most striking of all, Mr. W. H. Pickering, who preceded Mr. Lowell in his argument that the water supply in Mars is restricted, and in the recognition of the system of "oases," who further has had the opportunity of observing with Mr. Lowell's telescope and in the climate of Arizona, has not only frankly accepted our position, but has supported it by direct photographic proof. Mars, unfortunately, does not lend itself to photography, but the Moon does; and Mr. Pickering has found confirmation of our experiments as to the building up of straight-line systems from imperfectly seen details by comparing his drawings of certain lunar formations with actual photographs.

Stimulus and Sensation

By J. REYNOLDS GREEN, Sc.D., F.R.S.

IF we contemplate the enormous variety of form and structure which we find to exist among plants, and endeavour to study the reasons which we can readily trace for the diversity in these respects, the conviction is forced upon us that the story which is hidden there is one of stress and struggle, the result being a correspondence between the plant and its environment, so that the former can take advantage of all that is offered to it by the latter, and can resist successfully such deleterious influences as are inevitable from its situation. Hence different environment entails different structure. Moreover, as the environment is continually changing in some respect or other, the organism is continually involved in the struggle to adjust itself to the alterations thus besetting it. In the absence of power to maintain satisfactory relations, the plant becomes unhealthy, and after a time it perishes. Health, indeed, is but the expression of a satisfactory equilibrium gained and maintained between the plant and its surroundings.

XUM

As we cannot deny the extreme probability, perhaps we may say the certainty, that all plants now living have been descended from some primitive form, we can find in the history of different races the enormous effects which long-continued struggle for successful adaptation to a changing environment can achieve. The effect of change upon a single individual may be, indeed, must be, slight; but long-continued influence upon long series of descendants brings about a marked cumulative effect, and though we see little change in a generation, we are obliged to admit relatively enormous modification in the course of time. But though we can see little alteration in the individual, we may argue backwards and realise that no great change could occur in a race except by modifications of successive individuals of it. We must, therefore, look minutely to the individual to see what the properties are which in long years can effect such modifications of both form and structure as we find.

We have then to study what we may call the adaptation of the organism to its environment. At the outset, we must admit that such adaptation can take place only in two ways. Possibly, all plants whose constitutions are not in harmony with the changed conditions will perish, leaving more fortunate ones to carry on the race. This postulates that the plants of any particular generation are themselves varying slightly in their physiological properties. Possibly, on the other hand, the individual organism is possessed of a power of appreciating changes in its surroundings and of modifying its own behaviour accordingly. It may well be that both these hypotheses are to a certain extent true, and that they are co-operating to bring about the results we see.

There are strong grounds for accepting the latter of the two views as playing a very prominent part in the changes of the past. We can see certain phenomena occurring under our own eyes which are capable of interpretation in the way suggested, which, indeed, are inconsistent with any other hypothesis. A plant acted upon by a certain definite external influence modifies its way of behaviour in an equally definite manner. It is difficult to deny to the plant the power of perceiving the influence brought to bear upon it. The effect of the influence is technically called a *stimulus*, and the perception of a stimulus by the plant is known as a *sensation*. We have two factors then to consider, one external, the other internal, to the plant.

A more complicated question arises here. Is the perception of a stimulus, is a sensation, to be interpreted as implying any kind of *consciousness*? We have a stimulus, we have a response. What can we say of the interpretation of the one by the plant which makes it bring about the other? The problem is very difficult to speak with confidence upon in the present state of knowledge. The human mind shrinks at once from taking the affirmative view. No doubt, in the higher sense in which we interpret the word, no consciousness can have part in a vegetable organism, for this sense implies *thought*. It is difficult to suggest that a purposeful response implies any kind of volition. These operations are the immediate functions of the well-organised and most highly-developed nervous centres of the highest animals. But certain facts can be adduced which, at any rate, hint at the existence of such a limited consciousness as implies an appreciation of the nature of the surroundings.

To discuss this question at any length would, however, take us beyond the purpose of this article. We must confine ourselves to the question of stimulus and sensation as far as we can see them both at work in the course of ordinary vegetable life, leaving the full interpretation of the relation between them to be set aside for the present.

The nature of a stimulus first concerns us. We may take it for granted that there may exist for every plant, at any rate theoretically, a condition of adjustment when it is in absolute harmony with its environment—when temperature, illumination, moisture, rest, and whatever else affects it, are perfectly as the organism wants them, and when consequently its life is being regulated to the utmost advantage. Such a condition can be only momentary in any case, for the surroundings are in a constant state of change in many of these particulars, and the living substance of the plant is also exhibiting continual motility. For the maintenance of health, or even of life, it is essential that variations in the one shall be adequately responded to by variations in the other. The impossibility of securing indefinitely such a continual adjustment of relations is the cause of the cessation of life.

Such an alteration of the environment constitutes a *stimulus*. It may affect the plant in a hundred ways, causing various methods of response, and various degrees of intensity of response.

There are, however, other factors influencing its life which are not so easily realised by observation. Changes may arise in the condition of the living substance of the plant, set up perhaps by disturbances in its interior. The normal cause of chemical change associated with the nutritive processes may undergo a marked change in consequence of an alteration of the distribution or the direction of the stream of food in the plant's interior. Injury to the body of the plant may involve a re-distribution of energy or of material within it, which may have far-reaching effects upon the course of the vital processes. Variations in the supply of food, which may range between absolute starvation and over-engorgement, may produce very great changes not only in the outer life of the plant, but in the substances it produces in the course of its nutritive processes, and in the energy which it liberates. An insufficient supply of oxygen may provoke an almost entirely new series of chemical changes in connection with the production of such energy. These various factors and many others which might be quoted are to be regarded as stimuli, some of them internal no doubt, but all equally real and equally well appreciated by the plant as the more obvious external ones just described. Even more obscure stimulations may arise from chemical changes in the living substance itself, leading to a series of responses which, as they do not appear immediately related to visible stimuli, are often called automatic.

To appreciate more fully the part played by stimulation in the life of a plant, we may briefly consider a few of its more obvious forms. Consider the lateral incidence of light upon a growing seedling or young plant. If the latter is placed so that one side of its stem is more brilliantly illuminated than the opposite, a curvature soon appears in the part that is actively growing. This is of such a nature and takes place to such an extent as to cause the axis of the plant to take up a position in which it is parallel to the direction of the incident rays. It manifests itself in some cases very slowly, in others comparatively rapidly. This response to the stimulus of unequal illumination on its two sides is not confined to the stems of seedlings, but may be seen to a greater or less degree in parts of many adult plants. It is a matter of common observation that geraniums grown in a window all bend their stems and petioles towards the illuminated side.

In other cases the same stimulus may be responded to in quite a different manner. When certain young roots are exposed to it they curve so as to place themselves in the same position with regard to the incident rays, but with their growing apices in the opposite direction. Various tendrils, peduncles, and other organs respond in a similar manner. Leaves tend to place themselves across the incident rays.

Among the obvious difficulties which beset the course of a root in making its way through the soil is that of impinging more or less directly upon some particle which it is unable to displace. In practice it is nearly always found to be able to grow past such an obstacle. The situation affords us another example of stimulus appreciated and responded to. Contact with the apical portion of the young root causes an immediate departure from the straight line of growth. The behaviour of the organ can be studied on a germinating bean with great readiness. If such a structure be kept in moist sawdust till the young root emerges, then be transferred to a moist chamber and suspended therein, a small piece of hard substance, such as card-board, can be attached by a little cement to the side of the lip. The root at once begins to curve away from the side thus touched, and if the stimulation is maintained for some time the resulting growth will cause the root to grow into a loop. If a tendril of *Passiflora gracilis* have a small loop of thread laid upon a certain portion of it, it will curve at once and in about two minutes will assume the form of a helix. Other tendrils behave in a similar way on coming into contact with different hard supports, though the rapidity of their response varies considerably.

The nature of the response must, however, be considered before we can associate it in any co-ordinated fashion with the stimulus. Such co-ordination between the two must be put in evidence if we may fairly deduce such an appreciation as we can call sensation.

The first thing that strikes an observer is the evident *purposeful* character of the response. The position assumed in relation to the incidence of the lateral light is that which will ensure an equal illumination of the surfaces of all the leaves. These spread out at approximately equal angles with the stem in all its sides, and hence when the stem is parallel to the light source the greatest amount of sunlight falls upon the green surfaces of the plant, where the work of forming sugar under the influence of such light is taking place. The opposite effect produced upon roots is calculated to press them closely into the soil, where their absorbing hairs can have free play. The curvature of the tendril assists it to secure a holding for the plant, so that its weak stem escapes being trodden down and its leaves are enabled to reach light and air.

A less obvious consideration is afforded by the fact that the parts of the plant receiving the stimuli are in cases strictly localised. The receptive part of a root is just behind its apex; that of a young seedling stem is in about the same position. Not only is this part localised, but it is situated in quite a different part from that which effects the movement. The latter is caused by growth some half-inch or so nearer the base, at a part which is quite insensible to stimulation.

Another consideration which bears upon the question is that an extremely small stimulus is able to bring about a very considerable effect, and that there is no simple ratio between the intensity of the stimulus and the extent of the response. An instance of this is afforded by the behaviour of the tendril of *Passiflora* already described.

We can, therefore, associate stimulus and sensation and point to the response of the plant as evidence of both.

Saturn.

AT the beginning of May Saturn rises 2½ hours before the sun and telescopic observation may be renewed, though the planet will scarcely be far enough west of the solar orb to be presented under very satisfactory conditions. The ensuing apparition of this attractive object is likely to prove of great interest. His southern declination will be 3° less than it was last year and this ought to bring about an improvement in the definition.

In the summer of 1903 Saturn displayed the evidences of considerable activity in a number of bright and dark spots, of irregular form, distributed in about N. lat. 35° along the polar side of the northern equatorial belt ("KNOWLEDGE," Dec. 1903). In June, July, and August these markings were frequently seen, though but few observers appear to have retained them in view during the autumn months. The rotation period of the chief spot or spots was variously determined as follows:—

Observer or Authority.	Period. h. m.	Days of Observation.	Reference.
K. Graff ..	10 39·01	3	*Ast. Nach.* 3883.
J. C. Solá ..	10 38·4	32	*Ast. Nach.* 3894.
P. Fauth ..	10 38·0	18	—
*E. E. Barnard	10 38·8	40	*Ast. Journ.* 547.
L. Brenner ..	10 38·0	40	*Ast. Rund.* 47. *Observatory* 336.
	h. m. s.		
H. W. Wilson	10 38 4·8	75	*Popular Ast.* 108.
*G. W. Hough..	10 38 27	53	*Monthly Not.* Dec., 1903.
*G. W. Hough..	10 38 30·5	24	*Monthly Not.* Dec., 1903.
†W. F. Denning	10 37 56 4	129	*Monthly Not.* Jan., 1904.

* In these cases the identifications were uncertain and the resulting periods probably excessive.
† Mean value derived from observations of 18 spots.

As soon as Saturn can be successfully examined it will be important to ascertain whether the markings continue perceptible. Possibly, at the present time, the northern hemisphere shows nothing more than the beautifully symmetrical belts and zones which usually stripe the disc. The material of the differently tinted irregularities seen in 1903, which probably resulted from extensive eruptions affecting the atmospheric scenery, may have amalgamated with the ordinary bands of the planet and quite lost their distinctive outlines. And the region affected may remain quiescent for a time to be again disturbed by further outbreaks in the near future. The phenomena occurring on Saturn are, no doubt, very similar to those visibly taking place on Jupiter, and observation has taught us that on the latter planet one disturbance scarcely subsides before another forces itself into prominence. The spots common to certain latitudes of Jupiter possess some physical resemblances, and are characterised generally (though not invariably) by nearly identical rates of motion, according to the longitudinal current in which they are placed. The same thing is likely to be displayed on Saturn, and the few following years may be expected to furnish useful evidence on this point.

The spots on Saturn remained fairly conspicuous objects in December, 1903, and observers will probably redetect them during the present spring. If so, it will be desirable to obtain as many transits as possible, so that the individual objects may be satisfactorily identified and their periods of rotation redetermined.

The markings referred to certainly exhibited some of the vagaries which occasionally affect the features on Jupiter, for the rate of their motion underwent a decided acceleration at the close of the apparition. Several of the principal objects which, during the summer, gave a period of 10 hrs. 38 min. 3 sec. conformed with a shorter period of 10 hrs. 37 min. 50 sec. during the latter part of the autumn.

In regard to Saturn, the year 1903 will be remembered as one of considerable historic interest, for the rotation of the north temperate region was found to be 23½ minutes greater than that derived by Professor Hall from his equatorial spot of 1876, and the fact rendered conclusive that this planet, like Jupiter, displays atmospheric spots affected by large proper motions.

Mr. Crommelin's "Ephemeris for Physical Observations of Saturn, 1903-4" (*Monthly Notices*, December, 1903) will be found extremely useful in the further study of this interesting object.

W. F. DENNING.

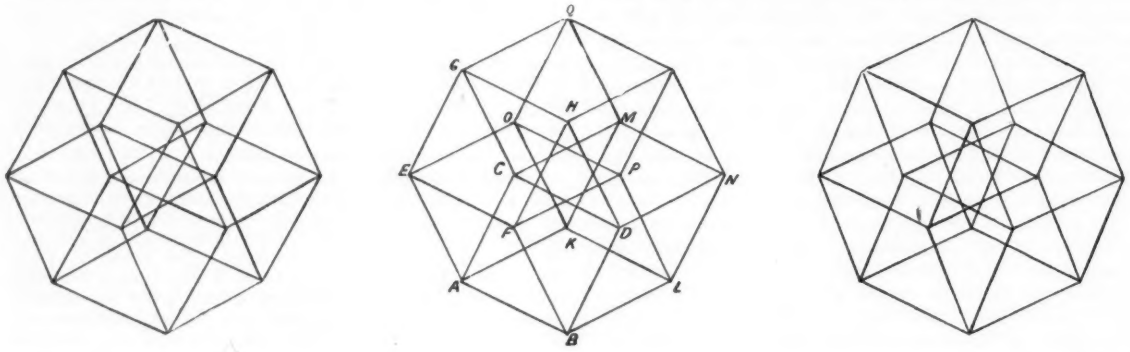
XUM

The Double Stereoscopic Projection of the Eight-Cell.

By G. H. BRYAN. Prof. Sc. D., F.R.S.

IN connection with Mr. Benham's paper on "The Super-Solid," it will be noticed that the diagrams of pairs of connected cubes, even when seen through a stereoscope, fail to convey the impression of being the projections of a *regular* figure.

A much better idea of the regular character of the "super-cube" or "eight-cell," as it is called by most writers, and of its connection with four-dimensional space can be acquired by choosing the plane of projection in such a way as to give the diagram a more symmetrical form, and by using two different stereoscopic projections instead of one.



In the annexed series of diagrams the central figure represents a symmetrical plane projection of the "eight-cell." It is not the only projection which is symmetrical, but it is a convenient one in which the edges and sides are well separated, and are nowhere near overlapping inconveniently.

When this figure and the figure to the left of it are viewed together through a stereoscope, the lines will stand out in relief, giving the impression of forming a solid figure in which the point H is nearest the observer, and K is furthest always. The points C, P appear to be *inside* the solid, and to be in the straight line joining E and N.

Now let the central and the right hand figure be brought into view in the stereoscope, and it will be observed that the whole aspect of the figure has altered. This time P is at the front of the figure and C is at the back, while the points H and K which were previously the nearest and furthest points appear to be inside the figure in the straight line joining Q and B.

As the same central figure is used in both cases, the traces of the two stereoscopic solids on the plane of the paper are, to all intents and purposes, the same. If, as assumed they both represent different aspects of the same figure the *distances* of the different points from the plane of the paper in the first place must be entirely independent of the distances from the plane of the paper in the second case. *These distances therefore correspond to different dimensions of space.*

In fact, if the first stereoscopic view represents the projection of a four-dimensional "eight-cell" in a solid space containing the first, second and third dimension, the other view represents the aspect of the same "eight-cell" projected in a space containing the first, second and *fourth* dimension.

Either of the two aspects shows a solid figure, which is *symmetrical* but not perfectly *regular*. It is not difficult, however, to convince oneself that the four-dimensional figure of which the two aspects are simultaneous projections is regular.

In regard to the fact that in either view two of the vertices (not the same two) appear *inside* the solid projection, a comparison of the two aspects will show that they are not really inside, but only look so owing to the direction of projection. This property is exactly analogous to the fact that if we draw the trace of a cube by projection on a plane, the projections of two of the vertices will be inside the polygon formed by the projections of the remaining vertices. It is only when the cube is viewed as a solid, or studied by means of its projections on *different* planes, that we become aware that all the vertices lie on the boundary of the cube.

A complete account of the regular figures possible in four-dimensional space, corresponding to the five regular solids enumerated in our text books of elementary solid geometry, is given by Mr. S. L. Van Oss in the Transactions of the Amsterdam Academy for 1899. The largest number of faces a regular solid can have is 20, the figure being known as an icosahedron, but in four-dimension space, the maximum number of boundaries is 600, and the projections of the "600 cell" shown in Mr. Van Oss's diagrams are very beautiful and symmetrical.

An interesting variation of the experiments described in this paper may be made by cutting out the two extreme figures and placing them simultaneously in the stereoscope, then inverting one of them and again placing in the stereoscope. In this manner two other aspects of the eight-cell will be seen. The scale of stereoscopic relief will, however, be different to what it was in the previous observations, but this will not much matter.

N-rays and Smell.

THE controversy concerning the objective reality of the N-rays suggests that to the proverb concerning the difficulties of accounting for taste, we shall have to add other maxims about the difficulties of accounting for sight and smell. On the one hand, M. Blondlot, Professor Charpentier, and M. Edouard Meyer continue in their respective spheres of investigation to add new facts each week—by means of papers read before the Académie des Sciences—to the common knowledge of the N-rays. On the other hand, Professor J. G. McKendrick and Walter Colquhoun, as well as other observers in Great

Britain, have failed to find any trace of the rays as objective realities; Professor C. C. Shenck has criticised, in a way which demands an answer, M. Blondlot's experimental methods and his alleged measurement of the N-ray's wave length; and Herr O. Lummer has suggested, in a paper read before the German Physical Society, that the observed phenomena are due to processes in the retina of the eye ("the contest between the rods and cones of the retina"). Meanwhile, the French observers go on undismayed by the stain of criticism and objection, and in *Cosmos* (April 2) Professor A. Charpentier gives the result of his observations on the connection between N-rays and the sense of smell. The N-rays, he observes, exercise a very distinct action on the olfactory sense. It can be shown if the nose is approached during the action of smelling by a body capable of producing N-rays, such as a piece of tempered steel or the closed fist, that the sensation of smell is increased. The experiment must be made with all necessary precautions, in still air, very slowly, with gentle and regular breathing, the odorous substance being maintained at a fixed distance nearly approaching to the extreme limit at which the olfactory organs can perceive it. The source of N-rays can either stimulate the sense of smell when the limit of perception is almost reached, or increase its intensity where it is already in existence. In both cases, the action is perceptible. It takes place when the source of the rays is approached to the root of "the nose or the base of the nostrils." If the mass of muscles in the thumb are placed against the nose, the slightest contraction of these muscles produces the effect already mentioned. Essence of cassia was the odorous substance usually made use of by Professor Charpentier, but the same results have been obtained by him from very different scents—essence of lavender, thyme, cloves, mint, camphor, ether, iodoforme, ammonia, and acetic acid among them. The N-ray action penetrates thin sheets of aluminium, and it is useful in order to eliminate the currents of air produced, in spite of all precautions, by displacing the source of the rays, to place a large sheet of this metal against the outside of the nose, and to conduct the experiment on the other side of it.

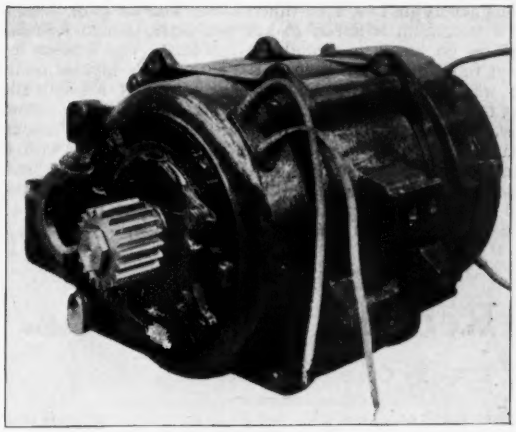
N-rays can, moreover, influence the olfactory sense when they are made to act at certain points on nerve centres if, for instance, the substance, which is the source of the N-rays, is placed near the middle of the forehead immediately above the place where the eyebrows meet. The effect is especially striking when the source of the rays is placed on the summit of the cranium a little in front of the place of union of the frontal and the two parietal bones.

This effect of N-rays is not confined exclusively to the organs of perception. The scent is increased to some extent when the radiating source is put near the flask containing the odorous substance at too great a distance from the nose to influence it directly. Professor Charpentier continues: "In the same way I have observed that the substances thus mentioned distinctly emit N-rays which traverse cork, and aluminium, but are stopped to a great extent by lead, and can give rise, like the other sources, to secondary radiations. As for the action of N-rays on the other senses, I have found, to begin with, a very distinct effect on the sense of taste. If a trace of some highly flavoured substance is put on the end of the tongue such as camphor, aloes, salt, or sugar, keeping the mouth open, the breath held, and the palate raised so as to avoid all olfactory influence, the approach of a radiating source, such as a ball of tempered steel, reinforces or creates the sense of taste. The same thing happens when salt or other substance is diffused in the mouth instead of keeping it on the end of the tongue. Are there points of the brain on which N-rays can act by determining an increase of the sense of taste? After experiments with different parts of the cranium, I have only found a certain degree of action in one parietal zone, next to that which acts on vision, perhaps a little behind it. The study of hearing is more difficult, because of the precautions to be taken in order to prevent the currents of air displaced by breaking the source of radiation interfering with the conditions of arrival of the sound. It can be done, however, by making use of secondary radiations. Now, in taking as the source of sound a watch held at the extreme distance at which the sense of hearing can perceive it, I have only clearly proved some increase of sound when the terminal plate was placed right above the ear at 7 to 8 centimetres from the orifice of the ear, which appears to confirm the idea of an excitation affecting the central centres of hearing.

The Single-Phase Motor in Germany.

THE single-phase traction motor which has been designed by the Union Electric Company, Berlin, according to Winter and Eichberg's data, and which is being tried on the Johannisthal-Spindlersfeld suburban line, near Berlin, is thus described by our Berlin correspondent:

The motor includes a stator similar to those of ordinary induction motors, containing a single-phase coil arranged in notches, and a collector armature which is designed like the armature of a direct current motor, and to which two sets of brushes with axes perpendicular to one another are fixed. The first set, the axis of which coincides with the axis of the stator coil, is short-circuited. It carries the working currents proper. These are induced by the field ϕ in the direction of the axis of the stator coil of a series transformer that is inserted in the main-current circuit, and carries only magnetising currents. The magnetising currents produce a transversal field F perpendicular to the field ϕ, by which, in conjunction with the stator current, the efficient torque is produced. The presence of two separated fields enables the motor to work



Single-Phase Motor in use on the Spindlersfeld Railway.

without sparking. The electro-motive force generated in a winding that is short-circuited by a brush through the induction of the field F is perfectly compensated as the speed of revolution increases, by the electro-motive force due to the rotation in the second field ϕ. That would be impossible in the case of monophase series motors, where, in the winding short-circuited through a brush, an electro-motive force independent of the number of turns, and incapable of being compensated, is induced.

Moreover, by the rotation of the armature, an electro-motive force is induced in the exciting circuit of the armature which is able not only to compensate perfectly the undesired electro-motive force of self-induction of the circuit, but at the same time the electro-motive force corresponding to the primary and secondary leakage. With an increasing number of revolutions the power factor will thus approach the value $\cos \phi = 1$, this value being maintained constant within wide limits on account of the unique regulation. Without any prejudice to motor efficiency, the air gap may therefore be made as great as in the case of direct current motors, and open stator notches may be used instead of closed notches. The ratio of the exciting transformer is regulated by the insertion or disconnection of windings. In the case of the series transformer being adjusted for a given ratio the motor will behave in a way quite similar to direct current series motors, both the current intensity and the torque having the maximum value at rest and decreasing for increasing angular speeds. In the case of the ratio of the series transformer being diminished, the characteristic curve of the motor is displaced so as to

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have the same torque as previously observed with a given number of revolutions M_1 appear only at a number of revolutions M_2 (superior to M_1). The same number of revolutions will now correspond with a higher torque than before, the torque at rest being evidently also higher.

The motor is started by altering the ratio of the regulating transformer. The current of the excitor brushes being thus interrupted at rest, the primary coil of the series transformer will act as a reaction coil, and the whole motor will be traversed only by a very small current. It will thus be unnecessary to open the primary coil of the motor when stopping. It is sufficient to open the exciting circuit (low tension coil) because the motor works only in the case of the exciting circuit being closed.

The motors of the Spindlersfeld cars have an output of about 100 H.P. hours; they have four poles and a monolateral air gap of 3 mm. The total weight of a motor, including the small toothed wheel, is 2140 kg., the weight of the exciting current transformers common to both motors being 1100 kg. As regards the arrangement of the connections, the direct current multiple unit system of the Union Elektricitäts Gesellschaft has been used and slightly modified. Two cars are being used in connection with the Johannisthal-Spindlersfeld trial runs, in addition to three trailers, each 16 tons in weight. The experimental trains are run on the same track as used for the regulation steam trains, and are inserted between the steam trains according to a fixed time table. The cars are designed for a maximum speed of 40 km. per hour, though speeds as high as 60 km. are sometimes reached. The motors have given full satisfaction even in the case of the highest strains, the whole train, including two motors and three trailers (155 tons), being often arranged and driven by the two motors only. The perfect independence with respect to the line tension has proved a special advantage as compared with the rotary current system, two-thirds of the line tension having been sufficient to maintain the regular service, while starting and running at a speed of about 30 km. was possible with 40 per cent. of the motor tension.

A. G.

Recent Explosions.

By CHARLES DAVISON, Sc.D., F.G.S.

INTERESTING evidence with regard to the propagation of sound by the atmosphere is afforded by the firing of heavy guns during reviews and sham fights, and by explosions in manufactories of dynamite and nitro-glycerine. Examples of the former class have been given in two recent papers.* During the great naval review at Spithead on June 26, 1897, held in honour of the late Queen's Diamond Jubilee, the sound of the first salute was heard as far as Weston, near Bath, at a distance of 71 miles. Again, on July 18, 1900, when the French President visited Cherbourg, a sham fight took place between two portions of the French fleet, giving rise to disturbances that were mistaken for earthquakes at many points along our southern coasts. The reports were heard from Dawlish and Exmouth on the west, to Brighton and Henfield on the east, the distance from Cherbourg to the latter place being 107 miles. Lastly, during the funeral procession of our late Queen, on February 1, 1901, the minute-guns were heard as far as Alderton, near Woodbridge, in Suffolk, which is 139 miles from Spithead.

In the present paper, I propose to describe similar evidence derived from two recent explosions, the first at Hayle, on January 5, of the present year, the second at Avigliana, near Turin, on January 16, 1900†.

* "The distance to which the firing of heavy guns is heard:" *Nature*, vol. lxii., 1900, pp. 377-379; "On the audibility of the minute-guns fired at Spithead, on February 1:" *Knowledge*, vol. xxiv., 1901, pp. 104-105.

† For the account of the Hayle explosion, I have relied on the reports which appeared in the *Western Morning News* (Plymouth), and on replies to a letter which the Editor of that paper kindly inserted. Dr. M. Baratta has published an interesting report on "Lo scoppio del dinamiti-ficio di Avigliana e la geo fiscia (16 gennaio, 1900):" Turin, 1900.

The Hayle Explosion of January 5, 1904.

The works of the National Explosives Company at Hayle are situated on waste land, known as Upton Towans, about two miles north-east of Hayle and between three and four miles east of St. Ives. To reduce all risks to a minimum, the separate buildings are isolated as much as possible; and, to lessen the loss of life, in case an explosion should occur, the number of men employed in any building is always small. It was no doubt owing to the observance of these precautions that the loss of life during the recent disaster was comparatively slight.

At the time of the explosion (10.55 a.m.), nitro-glycerine was flowing down a gutter from the precipitating house to the filtering house, the latter lying about 400 yards north-west of the former. Only one man was working in the precipitating house and three men in the filtering house. It appears that the precipitating house was the first to explode, and that, owing to the temporary connection by means of the gutter, the filtering house followed immediately. This conclusion rests on the evidence of an eye-witness; on the fact that persons to the south-east of the houses heard two reports separated by from 1½ to 2 secs., while those in the opposite direction heard only one; and on the condition of the gutter, which was not covered by the *débris* from the precipitating house. Both houses were, of course, destroyed, and their occupants killed instantaneously. As to the cause of the explosion, it can only be surmised—but the surmise is a probable one—that it was due to the fall of some heavy weight, either of one of the lead cups used to catch the droppings from the taps, or, more probably, of the lid of one of the tanks. In any case, the disaster must have been purely accidental in its origin.

The results of the explosion were visible for several miles around the works, chiefly in the breakage of glass. At Hayle, many windows were blown out. At St. Ives, the damage was estimated at not less than £200, but its distribution was partial, some houses suffering and others close at hand escaping; and it is worthy of notice, though the peculiarity has been recorded before, that the windows, especially in houses facing the works, were blown, not inwards, but outwards. Similar damage also occurred at St. Erth (3½ miles from the works), at Leedstown (4 miles), and, though to a much less extent, at Penzance (distant 9 miles).

A small oscillation of the ground was also noticed in the surrounding district. At St. Ives, according to my informant quoted above, the vibrations could not be distinguished from those produced by an earthquake. At much greater distances windows were shaken; but this must have been caused by air-waves. Observations of this kind were made at several places in Devon, at Ivybridge and Modbury (68 miles), near Torrington (74 miles), at Paignton (83 miles), Torquay (86 miles), and Teignmouth (88 miles).

The distribution of the places where the reports were distinctly heard is shown in the sketch-map in fig. 1. To the

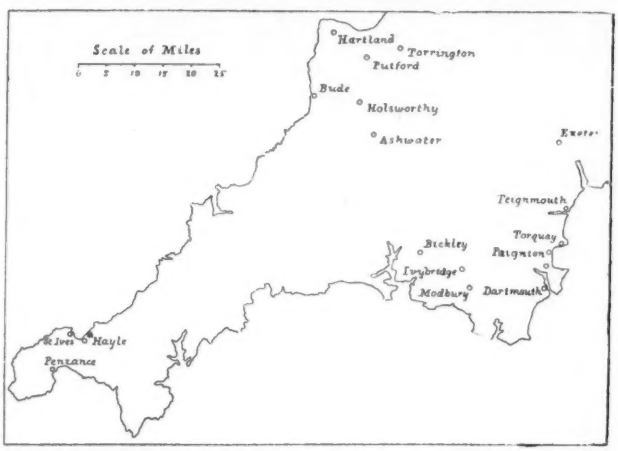

Fig. 1.

north-east, the explosion was audible around Holsworthy (62 miles from the works), Hartland (68 miles), and Torrington; and to the east at many places in South Devon as far as Exeter, which is not less than 90 miles from the centre of disturbance. Thus the sound must have been heard over nearly the whole of Cornwall, and the greater part of Devon, or over a total land-area of about 3000 square miles.

In the case of the minute-guns fired at Spithead on February 1, 1901, a curious anomaly was observed. In the immediate neighbourhood of Spithead, the sound-waves were almost or quite inaudible, and it was only at a distance of 50 miles or more up to about 80 miles that they attracted general attention. Owing to contrary winds, the sound-waves were refracted over the heads of observers near at hand, and were brought down again by favourable winds to the earth's surface at greater distances. The Hayle explosion affords another instance of this remarkable effect. At Camborne, which is only 4 miles east of the works at Hayle, no one, according to one of my informants, seems to have heard the reports, and, he adds, the wind at the time was blowing in the contrary direction.

The Avigliana Explosion of January 16, 1900.

The little town of Avigliana lies in the valley of the Dora Riparia, a tributary of the Po, about 14 miles west of Turin. As at Hayle, the various buildings which constitute the dynamite factory are isolated from one another, the whole being comprised within an area of about 50 acres.

The first and greatest explosion occurred in the building in which the nitro-glycerine was prepared, and which, at the time, was estimated to contain about 400 kilogrammes of this material. This was followed by the explosion of nearly 12,000 kilogrammes of dynamite and fulminating cotton contained in magazines which were probably ignited by the fall of burning materials from the first building destroyed.

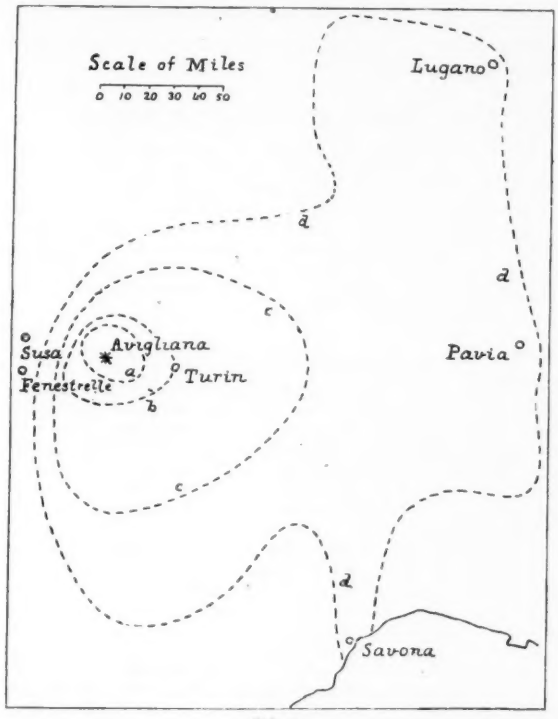

Fig. 2.

The curves in the accompanying sketch-map (fig. 2) give some idea of the distribution of the damage and other effects due to the explosion. The area of maximum destruction was practically co-extensive with the factory itself. At Avigliana, which is about half a mile distant, all the window-panes were broken, and in several of the older houses cracks were made in the walls and arches. Similar, though somewhat slighter, damage occurred at several neighbouring places, all included within the curve marked *a*, which contains an area of about 80 square miles. Outside this central area lies a zone bounded by the curve *b*, containing about 180 square miles and reaching to the western suburb of Turin, within which many, but not nearly all, windows were broken. In the next zone, lying between the curves *b* and *c*, the air wave was strong enough to make doors and windows rattle. It will be noticed that the dynamite factory is at some distance from the centres of all three curves, the last of which (*c*), indeed, extends 40 miles east of Avigliana and only eight miles to the west.

Beyond the latter curve the only effect observed was a rumbling sound like that of distant thunder or a cart of wood being unloaded. This was heard at considerable distances in some directions, but the peculiar form of the curve *d* which bounds it is in part, no doubt, owing to a defective series of observations. Towards the south-east it reaches as far as Savona (75 miles), towards the east to Pavia (87 miles), and towards the north-east as far as Lugano (99 miles). On the other hand, towards the west the sound was inaudible at Susa and Fenestrelle, both of which are only 17 miles from Avigliana.

Dr. Mario Baratta, who has studied this explosion, considers that the restriction of the curves towards the west is in great part due to the form of the land-surface. Without underrating the effects of the wind, the direction of which at the time of the explosion is unknown, he points out that the path of the waves would be obstructed by the mountain ranges lying to the west and south-west, while the open ground along the valleys of the Dora and Po would allow free passage to the sound-waves in other directions. Comparing the curves of fig. 2 with a contour-map of the district, he finds that the report of the explosion was never heard in places situated at an altitude of more than 1000 metres.

NOTES

ASTRONOMICAL.

A new form of Dipleidoscope.

IN a brief note communicated to the Royal Dublin Society, Sir Howard Grubb describes a simple little instrument for readily determining the true time by observation of the sun. The instrument in question, the dipleidoscope, was originally devised more than sixty years ago by E. J. Dent. It consisted of a right-angled prism so placed that the sun, when near the meridian, could be viewed in it obliquely, when two images were seen, the one due to reflection from the first surface, the other to double reflection from the two inner surfaces. The two images would therefore appear to move in different directions, and when the prism was properly set would overlap when the sun was on the meridian. The instrument, however, as originally devised, was open to some serious objections. The one image of the sun was faint, the other excessively brilliant, and neither being magnified, the observation was only a rough one. By covering one-half of the prism with a film of sulphide of lead, and by adding a lens of 20 feet focus, Sir Howard Grubb has been able to make the two images of equal brightness, and sufficiently large for an unskilled observer to determine the time to the nearest second.

* * *

Registration of Star Transits by Photography.

Sir Howard Grubb has made an exceedingly ingenious yet simple suggestion for getting over the difficulty which has been experienced in employing photography to register star

transits. The photographic plate must be made to travel if the registration is to be extended to the fainter stars, and the rate of motion should vary with the declination of the star. The suggested solution would place the object glass of the transit instrument in its horizontal axis, and the photographic plate would travel on the arc of a circle, the centre of which coincided with the centre of the object-glass. This arc would be carried by a polar axis, the prolongation of which would pass through the centre of the object-glass. If the polar axis were driven uniformly by clock work, as in the ordinary equatorial, the plate would always move at the proper rate for the declination of the star to which the telescope was pointed, and would always be in the focus of the transit telescope.

* * *

Burnham's Measure of Double Stars.

Amongst the decennial publications of the University of Chicago is a memoir by Professor S. W. Burnham on his "Measures of Double Stars," made with the 40-inch refractor of the Yerkes Observatory in 1900 and 1901. The memoir is one of very great importance, because the work undertaken by Mr. Burnham was the re-observation of stars which had been neglected, in most cases entirely, for some seventy or eighty years. The majority therefore are wide, or very wide, pairs, and could have been successfully dealt with by the instruments in the possession of not a few amateurs, so that the devotion to them of the largest telescope and the most gifted observer in the world is something to be regretted. But since there was none other fulfilling the duty, Mr. Burnham has performed a great public service in discharging it, and incidentally has succeeded in discovering some eighteen new pairs, some of which are evidently of very high interest.

* * *

Mr. Lowell on Changes in the Martian Canals.

Three papers recently published by Mr. Lowell carry his researches on Mars a distinct stage further. Two of these are issued as Bulletins Nos. 7 and 8 of the Lowell Observatory, and deal with the variation in colour of the Mare Erythæum and the alternating appearances of the canals Thoth and Amenthes. The third paper, entitled "The Cartouches of Mars," was communicated to the American Philosophical Society. In this last Mr. Lowell discusses some 375 drawings of the planet, made during the opposition of 1903 from January 21 till July 26. Eighty-five canals were observed, and each canal on the average might have been seen one hundred times. For each canal a curve or "cartouche" was drawn out to exhibit the percentage of times that it was observed when, from the presentation of the planet, it should have been visible, for different intervals after the summer solstice. The mean cartouches for the different zones are far from being convincing, and represent the smoothing out of many discordances. It may be granted, however, that there is some slight resulting evidence that on the whole the date of greatest distinctness for a canal falls later in the summer of Mars in proportion to its distance from the pole. This darkening of the canals proceeds towards the equator at a speed of 53 miles a day. Mr. Lowell considers this as motion in the face of gravity, the equatorial radius of Mars being eleven miles greater than the polar, and as demonstrating that the canals are waterways and that the water is raised to this height by artificial means. The Thoth and the Amenthes offer a case, according to Mr. Lowell, of alternative canals, the one canal being visible in one season and the other in another. Mr. Lowell also finds that the Mare Erythæum shows a distinct blue-green tint at the time when he infers there is most moisture in the region and a chocolate-brown when there is least, a change he ascribes to the decay of vegetation.

* * *

Sunspots and Terrestrial Magnetism.

Professor Riccò contributes an important memoir on this subject to the Società degli Spettroscopi Italiani. He refers at length to Mr. Maunder's recent paper on the nineteen great magnetic storms of the last thirty years, and fully adopts his conclusion that there is a real connection between sun-spots and such storms. Mr. Maunder found that the storms began on the average 26 hours after the transit of a great spot across the central meridian of the sun. Professor Riccò finds that the maximum violence falls about 45½ hours after the transit. As the mean duration of a storm is 33 hours, the two determinations are almost precisely in accord. Referring to a number of suggestions which have been made to explain the sun's influence on terrestrial magnetism, Professor Riccò appears to favour that of Arrhenius, who suggests ions, driven from the solar surface by reason of the pressure of radiation; their velocity being nearly that indicated by the interval mentioned above.

ZOOLOGICAL.

Early Opening of the Right Eye.

IN a note to certain observations on the gestation of the badger, published in the March number of the *Zoologist*, Mr. A. Heneage Cocks records the following very remarkable circumstance: "I have never seen the fact noticed," he writes, "that the right eye of young mammals opens before the left. I do not remember an exception among wild animals, nor even among domestic animals, though it is very likely some occur in the latter class. From the time the lids of the right eye begin to part to the time the left eye is fully opened takes generally from 36 to 40 hours." The fact is as new to us as it is to Mr. Cocks, and requires an explanation. The suggestion naturally occurs that the phenomenon is connected with "right-handedness" in the human species; but before such an explanation can be accepted, we want to know whether carnivorous and rodent mammals, and the members of such other groups as have the young blind at birth, display a similar preference for using the right limb. The horse, it is well known, displays a decided tendency to "lead with the left foot;" but in this species, in common with other ungulates, the young are born with their eyes wide open. And what holds good in this respect with domesticated horses may not obtain among carnivores and rodents.

* * *

The "Pearl Organs" of Fishes.

The males of certain species of North American fishes develop during the breeding season what are known as "pearl-organs." These are hard spine-like thickenings of the epidermis, sometimes forming rows on the sides of the tail and on the anal fin. Their use long remained unknown. Mr. J. Reighard, of Michigan University, finds, however, that they are employed by the males of some species for fighting and in building their nests, while in all the species they are used for holding the spawning female.

* * *

Whale Collisions.

Two instances of the sudden destruction of whales by collision have recently been recorded in the daily papers. In the one instance the look-out on a liner noticed a large whale disporting himself on the surface of the water immediately ahead, but, thinking that the monster would get out of the way in time, the vessel was allowed to pursue her course. Instead, however, of moving, the whale remained where he was, and was caught "amidships" by the bows of the steamer, which cut him completely in two. For two or three miles, it is said, the vessel ploughed her way through water crimsoned with the leviathan's blood. The second case is recorded in a telegram sent from Vladivostok on March 30. "A violent explosion," runs the message, "recently occurred at sea in Possiet Bay, the cause of which could not be ascertained. Two days later the body of an enormous whale was washed into the bay by the tide, the creature having evidently collided with and exploded a mine."

* * *

Monkeys and Altitude.

A recent issue of the *Atti* of the Roval Academy of Rome contains an account of the effects produced on baboons and monkeys by conveying them to a high elevation on Monte Rosa. The ill effects seem more pronounced than in the case

of human beings. The action of the low barometric pressure appears very similar to that of narcotics, producing at first unusual activity and excitement, followed by sleepiness, insensibility, and, finally, death.

* * *

The Brain of Man and Apes.

For many years Professor G. Elliot Smith, of the Egyptian Government School of Medicine, has been devoting his attention to the study of the brain in man and other mammals. Recently, in the *Anatomischer Anzeiger* (Jena), he has published a preliminary account of what appears to be an exceedingly important discovery. The human brain, as known by European specimens, has been supposed to differ from that of apes and monkeys by the absence of the so called simian fold ("Affenspalte") on the posterior portion of the main hemispheres. On studying a large series of Egyptian and Sudani brains, Professor Smith finds, however, that this simian fold, or sulcus, can be distinctly recognised.

"It is easy," he writes, "to select examples from the series of Egyptian and Sudanese brains in my possession in which the pattern formed by the occipital sulci on the lateral surface of the hemisphere in individual anthropoid apes is so exactly reproduced that the identity of every sulcus is placed beyond reasonable doubt. . . . And if we take individual examples of gorilla brains it becomes still easier to match the occipital pattern of each of them to numerous human brains. . . . It is easy to appreciate the difficulties which have beset investigators of European types of brain, and to understand the reasons for the common belief in the absence of the supposed distinctly simian sulci in the lateral aspect of the occipital region of the human brain."

Thus disappears one more of the supposed structural distinctions between man and his nearest relatives.

* * *

Zebra Taming at the Zoo.

All interested in the progress of the Zoological Society's Menagerie in the Regent's Park, and the attempts now being made to render it more attractive to the general public, will have heard with unfeigned regret of the sudden death of the Grévy zebra stallion shortly after the first trial at breaking it for the saddle. With regard to the experiments made for taming all the specimens of the zebra at present in the collection, it appears that the smallest and quietest of the three mares was some time ago broken in with very little trouble. On March 15, "Jess," a larger and somewhat less docile mare, was taken in hand, with most successful results; and the same afternoon the third mare was handled with equal success. All three mares have since been going about quietly in harness, although it was deemed advisable not to take "Jess," as being by far the most powerful, beyond the limits of her paddock. On the following day, March 16, the Grévy stallion was taken in hand, although it was never intended that he should be employed for riding purposes. Although some temper was displayed by the stallion, he was eventually broken with complete success. During the next two days he seemed perfectly well, but he showed signs of being out of condition on Saturday, and, after refusing to get up on the morning of the Sunday, he died that night.

The post-mortem examination was made on Wednesday, March 23, by Dr. Salaman, Director of the Pathological Institute at the London Hospital. The immediate cause of death was heart-failure, but Dr. Salaman was unable to find evidence of the actual cause of failure; the complete absence of signs of injury or disease being similar to the case of a Grant's zebra examined by him at the beginning of March, which had died in the Gardens without having undergone any training or breaking-in.

Although it is obviously impossible to be certain that the death of the Grévy was unconnected with the breaking-in, it is satisfactory to know that there was no sign of injury to any of the internal organs. The bones were, however, unusually brittle, and the stallion was much older than had been supposed. Our readers will be glad to hear that this untoward event is not to be allowed to interfere with the progress of zebra-training.

The Collections of the "Discovery."

According to the daily papers, the results of the expedition of the "Discovery" to the Antarctic do not appear to have added anything very striking to our biological knowledge. So far as zoology is concerned, the most important item is, perhaps, the discovery of a "primitive type" of insect. Valuable information with regard to the bird-life is, however, said to have been obtained. Most important of all appears to be the discovery of a number of fossil-plant remains, which are said to confirm the theory of a former land-connection, by way of "Antarctica," of the southern continents and islands.

BOTANICAL.

An Abnormal Fern.

Aspidium anomalum is a fern found growing at high elevations in Ceylon. It closely resembles the British *A. aculeatum*, of which it may be merely a form, and very remarkable on account of the sori being developed on the upper instead of the under side of the fronds, the usual position for them. The plant is now in cultivation in this country, its large handsome fronds rendering it of considerable horticultural merit. The species was first described by Sir William Hooker nearly half-a-century ago under the name of *Polypodium anomalum*, and he regarded it as an abnormal form of *P. vestitum*. He found that the indusium was entirely absent even in the youngest stages of the fructification, while in *P. vestitum* it was very early deciduous. Other ferns are known to occasionally develop a few sori on the upper side of the frond, as in *Deparia Moorei*, where they are confined chiefly to the margin, and sometimes in *Asplenium Trichomanes*. Sir William Hooker refers to a specimen of this species, collected in Italy, in which, in addition to the numerous sori on the under side of the frond, there was one pinna "bearing a solitary sorus on the disc of the upper side." In the specimen from which *Aspidium anomalum* was first described a few sori were found on the under side of two or three pinnules of a frond.

* * *

A Primitive Food.

Professor F. V. Coville has just published an interesting paper on a primitive food of the Klamath Indians, produced by a congener of our yellow water-lily (*Nuphar luteum*), and known under the native name of Wokas. This plant is *N. polysepalum*, called by American botanists *Nymphæa polysepala*, and is found in great abundance in the reservation occupied by the Klamath Indians in the south-western corner of the plateau of eastern Oregon, at the eastern foot of the Cascade Mountains. A huge marsh in this reservation, known as the Klamath Marsh, contains no less than ten thousand acres of the Wokas, which flourish to the exclusion of almost every other kind of vegetation. The seeds are subjected to various tedious processes by the natives and ultimately furnish a wholesome farinaceous food, which is regarded as a great delicacy, and which Professor Coville thinks might be successfully brought into commerce as a breakfast food, though he does not consider the cultivation of the plant for commercial purposes to be feasible, and the supply of the seeds would be dependent on the wild crops. The order Nymphæaceæ is not important economically. The seeds of the *Victoria regia* are eaten by the natives of Guiana and Brazil, and the stem of the Sacred Lotus (*Nelumbium speciosum*) "is used as food in India and China, though probably only in times of scarcity."

PHYSICAL.

On a Novel Radiation Phenomenon.

MR. J. J. TAUDIN CHABOT* some time ago ascertained whether selenium in its conductive modification, being sensitive to light, may give rise to radio-active phenomena. To this effect he used a selenium cell of the Shelford Bidwell type, the

* *Physikal Zeitschr.*, No. 4, pp. 103-104, 1904.

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effective mass of which was uniformly distributed on the surface of a platinum wire. After having been in the dark for many weeks, the platinum selenium surface was covered, at a red illumination, with a sheet of silver bromide jelly to which a sensibiliser absorbing the yellow and green rays was added, an aluminium strip bent at right angles being interposed. After the whole system had been kept in the dark for another 48 hours, the same experiment was repeated, using a fresh silver bromide jelly sheet, while a current of about 110 microamperes traversed the selenium. Now the following results were observed on the developed jelly sheet :—

In the first case, some bright spots corresponding apparently to the outline of the aluminium angle were noted on a dark background, whereas, in the second case, a dark silhouette of the whole of the angle without any details resulted on a bright background, some brighter narrow transversal bands being visible at the same time. These bands were produced more efficiently in the case of repeated expositions, thus allowing of ascertaining that they are due either to the parallel platinum wires or to the selenium interposed between each two of these, or finally to the points of contact between the platinum and selenium, where the Peltier effect must give rise to an evolution of heat either positive or negative, on the passage of the current.

On continuing these experiments, Mr. Chabot noted the fact that the back of the plate bearing the platinum selenium wire was equally capable of affecting the silver bromide jelly, dark silhouettes on bright background being then obtained. As to the question whether these results are an evidence of the existence of some novel radiation, or else an emanation from the surface of conductors, the author hopes to publish in due course some further investigations allowing of more definite conclusions being drawn.

* * *

Radium and Heat.

In the course of an experimental investigation of the influence of radium on the rate of cooling of a body placed in a gaseous medium, Mr. Georgiewsky, in a paper recently read before the Russian Physico-Chemical Society, arrives at the following conclusion :—

1. The rate of cooling of heated bodies in the various gases is not modified under the influence of radium.

2. The rate of cooling of non-electric heated bodies placed in one of the gases examined (hydrogen, lighting gas, air and carbonic acid) on being exposed to the action of radium is augmented in the case of the heated bodies being electrified. The rate of cooling in this case will augment not only under the simultaneous influence of the α, β and γ rays of radium, but as well under the exclusive action of β and γ rays.

3. The increase in the rate of cooling of a heated body is greater as the body is negatively charged.

4. The relations existing between the increase in the thermic conductivity and the potential of a charged and heated body may be represented by means of curves analogous to those by which Mr. Townsend expresses the connection between $\alpha : p$ and $X : p$ for the same gases (*Phil. Mag.* 6 ser. V. 5, p. 571).

A. G.

ORNITHOLOGICAL.

By W. P. PYCRAFT, A.L.S., F.Z.S., M.B.O.U., &c.

Breeding Habits of the Common Buzzard

(*Butea vulgaris*).

PROFESSOR J. H. SALTER gives an exceedingly interesting account of his observations on the nesting habits of the Common Buzzard in the "Zoologist" for March. Of the three young which are almost invariably hatched, he remarks that, in the hill districts, the oldest bird will commonly kill one or both of the younger nestlings; apparently for the purpose of securing their share of the food brought by the parents. In support of this view he points out that this unnatural behaviour is not noticeable when the young are reared in the more fertile valleys where food is plentiful.

He also describes a curious habit which the parents have of decking the lining of the nest with freshly-plucked leaves and twigs, especially of birch, and rowan, and bracken.

Birds breeding in Wales furnished the material for this extremely interesting history.

* * *

Greenland Falcon in Donegal.

It has just come to light that an immature bird of this species was trapped in Donegal in December last. This makes the thirty-second record of this species for Ireland, and the tenth for Donegal.

* * *

Nutcracker in Northamptonshire.

A trap set for "vermin" in February last, at Tywell, captured instead a Nutcracker, whilst one is reported to have been seen in Devonshire during the same month.

* * *

The Emperor Penguin.

A statement has been going the round of the daily papers to the effect that one of the results of the newly-returned *Discovery* Expedition to the Antarctic has been the capture of the Emperor Penguin, a bird which had "not previously been found in these regions." Of course this is a mistake; but we are glad to learn that the eggs of this bird have been taken, for they have not hitherto been, and will therefore form a welcome addition to the collections of the National Museum at South Kensington.

All communications intended for this column should be addressed to :—

W. P. PYCRAFT,
Natural History Museum,
South Kensington.

REVIEWS OF BOOKS.

FIRST CAUSES.

The Old Riddle and the Newest Answer. By John Gerard S.J., F.L.S. (Longmans.) The old riddle which the Rev John Gerard tries, not to answer, but to state, is that which asks whether it is possible to explain the universe without admitting the existence of a Creator. The answer he gives is that no theory which has yet been formed can relieve us from the necessity of imagining a First Cause; there must have been a God, a Divine Intelligence greater than any intelligence which man can attain. Mr. Gerard's conclusion is well stated in a quotation from the late Professor Baden-Powell—"That which requires thought and reason to understand must be itself thought and reason. That which mind alone can investigate or express must be itself mind. And if the highest conception attained be but partial, then the mind and reason studied is greater than the mind and reason of the student. If the more it be studied the more vast and complex is the necessary connection in reason disclosed, then the more evident is the vast extent and compass of the intelligence thus partially manifested . . . ." But though we have no quarrel with the conclusion that Mr. Gerard reaches, and though we may admit that it has been expressed in varying forms by the greatest of scientific men—by Kelvin, by Lamarck, by Sylvester, even by Huxley—there is a distinct objection to the means he has taken to reach it. He opposes the theory of Evolution by the doctrine of Design. A very large part of his volume is occupied by an attack on Darwinism, which we cannot even admit to be a fair attack. Darwin's theory is not infallible; its too zealous advocates have sometimes stretched it farther that it can legitimately be held to go. In any case it is but a working model, and, like the atomic theory, or the theory of the ether, or the chemical theory of ionic dissociation, or the new theories based on radio-activity, it is to be regarded not as a complete explanation, but as a hypothesis which enables us to account for many of the facts. Even if it were completely true, it would not prejudice the belief in a Creator; if it were proved entirely mistaken it would not strengthen that belief. Why

then assail it as a factor in the argument? If, on the other hand, the Darwinian theory be assailed on other than dialectic or theological grounds, then the first necessity is to be scrupulously fair, meticulously exact. We have not space to consider critically all the quotations which Mr. Gerard brings forward as evidence against it; but we may briefly refer to one part of his case, which is contained in the chapters on the geological record. He quotes with approval the attacks which Mr. Carruthers made in 1876 as President of the Geologists' Association, and later in book form (1898), on the incompleteness of the botanical fossil record, and its failure to show any connecting link between the greater divisions of plants. But Mr. Gerard entirely ignores the work which has been done since 1898 by Professor A. O. Seward, Dr. D. H. Scott, and Professor F. W. Oliver in fossil botany, and the opinions expressed by them. To quote but a single instance: Dr. D. H. Scott and Professor F. W. Oliver have within the last twelve months shown reason for connecting the Ferns with the Cycads; and have exhibited in Lyginodendron a seed-bearing fern. Not, however, to go into too great detail, we may quote from Professor Seward's British Association address an observation made by Darwin himself on the imperfection of the geologic record, "The crust of the earth, with its embedded remains, must not be looked at as a well-filled museum, but as a poor collection made at hazard and at rare intervals." And the transitions of form and species are not incompatible with evolutionary theory.

A Chemical Conception of the Ether. By Professor D. Mendeléeff. (London: Longmans, Green, and Co.) The discovery of the radio-active properties of some of the metals, and the probability which Lord Kelvin remarked, that most substances are radio-active to a greater or less extent, has been one of the corroborative facts to sustain the electro-atomic theory of matter. That theory has been hesitatingly received by many chemists, who have not hesitated to dispute the objective reality of atoms—regarding them merely as vehicles for expressing relations between the elements—and who have seen in the extension of the theory so as to take in "atoms of electricity" or "electrons," or "twists in the ether," an unprovable hypothesis which they do not need to explain chemical inter-action. The attack on the physicists' conception of the atom of matter as an imperceptibly small system of forces in which electrons revolve at enormous speeds and possibly in concentric rings (not unlike a solar system in miniature, or the rings of moons about the planet Saturn) has not hitherto been very well directed. It has in at least one instance put forward an untenable explanation of some of the facts of radiation; and while ignoring the fact that the "electron" theory does explain the radiation of radium and thorium very well, has offered no alternative theory. Professor Mendeléeff's theory of the ether removes, however, the latter reproach, and offers a supposition which, though awaiting the test of mathematical examination on the part of the physicists, is an extremely interesting one. He boldly sweeps away the anomalies of believing the ether to be an all-pervading substance—rigid as steel, yet interpenetrating all matter; frictionless, but without weight—by imagining it to be a gas that has weight and substance, though it is of such extreme tenuity that it is capable of interpenetrating all other substances and incapable of offering a measurable resistance to their passage among its molecules. Its insusceptibility to chemical combination is to be regarded as similar to a similar inertia on the part of helium or argon, or the gas emanating from radium; its imponderability is not real, but due merely from the absence of any known means of weighing it. Professor Mendeléeff calculates that this theory would fulfil the requirements mathematically demanded from it if the ether, the lightest element, and its particles and atoms had an atomic weight nearly one-millionth that of hydrogen, and travelled with a velocity of about 2250 kilomètres a second. We need not follow Professor Mendeléeff's theory in all its details, but it will not be uninteresting to summarise the way in which it responds to the demands put on it to explain radio-activity. Although the ether, or, as he calls it, the lightest of gases, x, has no power to form stable chemical compounds, it would not be deprived of the faculty of dissolving in, or accumulating about, large centres of attraction—like the sun among heavenly bodies, or the heavy uranium and thorium atoms. If the ether be a gas x it must naturally accumulate from all parts of the universe towards the heavy suns, just as the gases in the atmosphere accumulate in a drop of water. Similarly it will accumulate towards the heaviest atoms of thorium or uranium. *If such a special accumulation of ether atoms about the molecules of radium and thorium be admissible, they might be expected to exhibit peculiar phenomena determined by the emission of a portion of this ether held by particles of normal mean velocity and by new ether entering into the sphere of attraction.* In short, the theory of the great Russian chemist is not unlike in form that explanation suggested by Sir William Crookes and Dr. Johnstone Stoney, and partly confirmed by Lord Kelvin, that the radiation of radium, thorium, &c., is sustained by energy from without rather than from within.

The Essential Kaffir. It is to the human interest of the Kaffir that Mr. Dudley Kidd devotes himself in his valuable and entertaining book, "The Essential Kaffir." (Adam and Charles Black.) He uses the word Kaffir in its broadest sense to include all the dark-skinned tribes of South Africa; his information concerning the people of whom he writes is intimate and varied, comprising the gleanings of a dozen years, repeated visits to their tribes, visits in which he associated with them in terms of intimacy, slept in their huts, watched their habits of life and their social and religious customs, memorialising them in many admirable and curious photographs which add greatly to the value and interest of his book. There is, for instance, the photograph of the mother feeding her baby with sour milk out of her hand, while a lean dog watches the operation with sympathetic interest. In the next photograph the dog is being utilised as a napkin to lick the baby's face clean, while the mother holds its unwilling countenance steady with one hand while she guides the dog's head with the other. Mr. Kidd describes a night spent in a Kaffir hut in company with the Kaffir family and such household pets as a calf, a dog, roosting fowls, and others who shall be nameless, but who could scale even sandbanks of Keating. One feels as one reads that self-sacrifice in the cause of knowledge could go no further. Very interesting are the chapters on Kaffir mental characteristics, on their musical instruments and games, and on their religious beliefs. Of their mental powers he notes the curious fact that the native children sometimes absorb knowledge with a singular precocity, but as they develop their brains, as it were, seem to stop growing, their energies appear to be absorbed in their bodily development, and whether caused by "mechanical formation of the bones of the skull or not, must be left to men of science to settle; yet the fact of stunted mental development remains." At the same time the natives are remarkable for their extraordinary memory of facts which interest them, such as the precedents in a legal case. In a book where every page is interesting, an adequate idea of its contents can hardly be given in so short a space. All such people as the Kaffirs here described must rapidly lose much of their individual character in contact with other civilisations, and a book that crystallises their essential characteristics from intimate observations has a more than ephemeral interest.

Physical Chemistry in the Sciences, by Jacobus Van't Hoff. (Chicago: The University Press.) To the Decennial publications of the University of Chicago have been added the series of lectures which were delivered there by the German chemist, Van't Hoff, and which deal with "Physical Chemistry in the Service of the Sciences." The lectures, lucid, terse, concentrated, deal with Physical Chemistry in Pure Chemistry, in Physiology, in Geology, and in Industrial Chemistry. From the last-named chapter we may make an extract which should be very serviceable in bringing home to the British nation the true reason for the growing strength of the German competitor in industries that for many years were chiefly British. "There exists in Germany," says Van't Hoff, "a very beneficial co-operation between laboratory work and technical work. Both go as far as possible hand in hand. After physical chemistry had made several important advances, and was firmly established in such a way that pure chemistry was assisted by co-operation with it, Professor Ostwald judged correctly that this co-operation would be valuable in technical directions. In this belief he founded the Electro-Chemical Society. . . . All the most conspicuous chemical industries of Germany are represented in the Society, which has its own organ of publication. Nor has the stimulus to this co-operation come purely on the

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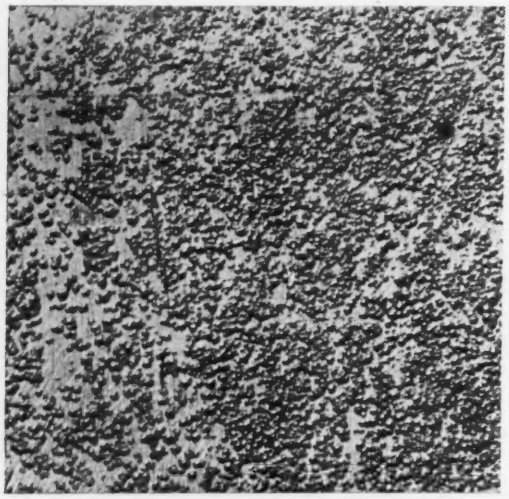
scientific side. That it comes from both parties may be seen, for example, in the fact that a year ago Professor Goldschmidt, of the University of Heidelberg, was asked by the Director of the 'Badische Anilin-und-Soda Fabriken' to give a series of lectures on this branch of science before the chemists of the factory, and did so with great success. An opening up of new points of view, rather than immediate practical results, was expected to flow from these lectures," all of which should



A plate of tin affected by Tin Disease (enlarged one and a half times).
(From "Physical Chemistry in the Sciences").

strengthen a case, already overwhelming, for the establishment of English Charlottenburgs. From Van't Hoff's lecture on Industrial Chemistry, we take also a plate illustrating a curious so-called disease of tin. It is rather a transition of tin from one form to another, and has been recognised as of actual occurrence since the time of Aristotle. Van't Hoff described the beautiful methods, largely due to the investigations of Schaum and Cohen, by which the conditions which influence this extraordinary change have been determined.

BOOK NOTICES.

Geometry. In addition to "A School Geometry (Parts I.—IV.; IV., V.)," by H. S. Hall, M.A., and F. S. Stevens, M.A. (Macmillan), which we received last month, and which provides a course of elementary geometry based on the recommendations of the Mathematical Association and on the schedule recently proposed and adopted at Cambridge, we have received also "Elementary Geometry" (Parts I. and II.), by Cecil Hawkins, M.A. (Blackie), which departs even more boldly than other works based on the tenets of mathematical reform, and which, with practical illustrations, takes pupils and classes, not through the routine of Euclidian propositions, but acquaints them by progressive stages with the ascertainable properties of "Intersecting Straight Lines," "The Triangle," "The Circle," "Polygons," and so on to areas and to numerical theorems treated numerically.

Domestic Economy Reading Books, Vol. II., "The Marshfield Maidens and the Fairy Ordina," by Mrs. W. H. Wigley (Thomas Murby, 3, Ludgate Circus Buildings, E.C.).—Simple lessons in household duties are conveyed in narrative form.

Logarithms for Beginnings, by Charles Pickworth (Whittaker and Co., 2, White Hart Street, E.C.).—A simple introduction to the study of the subject, intended to give a more detailed and practical explanation of logarithms and their various applications than is to be found in text-books on algebra and trigonometry.

Worked Problems in Higher Arithmetic, by W. P. Workman and R. H. Chope (W. B. Clive, University Tutorial Press).—A collection of problems in higher arithmetic, intended especially for students who are preparing for Civil Service Examinations. It will also be of service to teachers.

Tables of Multiplication, Division, and Proportion, by Robert H. Smith, M.I.M.E. (Archibald Constable).—These elaborate tables will be useful in the ready calculation of quantities and costs, estimates, interests, wages and wage premiums, &c.

The Story of Creation, by Edward Clodd (Watts and Co Sixpenny Edition, with numerous illustrations and good type).—It gives an account of the theory of evolution in clear and popular form, dealing with the distribution of matter in space, the past life history of the earth, present life forms, the origin of life and of species, and social evolution.

An Agnostic's Apology, and other Essays, by Sir Leslie Stephen, K.C.B. (Watts and Co. Sixpenny Edition.)—Contains Essay on "Materialism," Newman's "Theory of Belief," "Toleration."

Remarkable Comets, by William Thynne Lynn, B.A., F.R.A.S. (Sampson Low, Marston, and Co. New Edition).—It reviews briefly the most interesting—perhaps we should say the most popular—facts in the history of Cometary Astronomy.

A Safe Course of Experimental Chemistry, by W. T. Boone, B.A., B.Sc. (W. B. Clive, University Tutorial Press).—A short course of chemical experiments, designed to train students in solving elementary problems by experiment, in accuracy in their work, and in reasoning from observation. It is especially intended for the London matriculant who intends to take the Intermediate Science Examination, or for students in training colleges who have to take the prescribed course in general elementary science.

Second Stage Botany, by J. M. Lowson, M.A., B.Sc., F.L.S. (W. B. Clive, University Tutorial Press).—This is an adaptation of the "Text Book of Botany" to the requirements of the second stage examination of the Board of Education, South Kensington. The first part of the book deals with morphology, histology, physiology; the diagrams and illustrations are numerous and clear, and will be very helpful to students.

Modern Navigation, by William Hall, B.A. (W. B. Clive, University Tutorial Press), is intended primarily as a text-book for students of navigation and also as a handbook for navigators. It will be found useful in the various examinations of the Royal Navy, the Mercantile Marine, and the Board of Education. The explanation of compass deviations and tides will introduce the student to more detailed works on the subject.

Pocket Edition of the Works of John Ruskin (George Allen).—A small and pretty edition of Ruskin reprints, light to hold, and pleasant to read. "Sesame and Lilies," which deals with "The Mystery of Life and its Arts," and insists that "those of us who mean to fulfil our duty ought first to live on as little as we can; and secondly to do all the wholesome work for it we can, and to spend all we can spare in doing all the good we can."

The Crown of Wild Olive; Essays on "Work and War and the Future of England," and "Lectures on Art"—Essays on the Relation of Art to Morals and the Relation of Art to Use. These three volumes contain some of the most strenuous common-sense and right-thinking in Ruskin's works.

Messrs. John Wheldon and Co., of Great Queen Street, have issued a clearance catalogue of a miscellaneous collection of books. The volumes include works on botany, entomology, and ornithology. There are especially to be noted some works on fungi and publications relating to meteorology.

Messrs. Isenthal's new catalogue is well worth attention for the completeness of the Röntgen-ray and allied apparatus which their manufacturers offer. The very large and greatly increasing numbers of devices used in electro therapeutics and in the new methods of the light treatment of disease are specially noticeable.

Messrs. Harry W. Cox's new catalogue of X-ray and high-frequency apparatus includes an extension of their previously issued practical hints to beginners. These hints, covering work with X-ray coils, mercury and other interrupters, and describing the best methods of connecting rheostats and charging accumulators from the mains, are extremely useful, and much to the point. They add distinctly to the value and interest of the catalogue.

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BOOKS RECEIVED.

A Systematic Survey of the Organic Colouring Matters, by A. G. Green, F.I.C., F.C.S. (Macmillan.) 21s. net.

My Airships, by A. Santos Dumont. (Grant Richards.) Illustrated; 6s. net.

Five Years' Adventures in the Far Interior of South Africa, by R. Gordon-Cumming. (John Murray.) Illustrated; 2s. 6d. net.

Radium and all About It, by S. Bottone. (Whittaker & Co.) Illustrated; 1s. net.

A Text Book of Geology, by W. Jerome Harrison, F.G.S. (Blackie & Son.) Illustrated; 3s. 6d.

Dyes, Stains, Inks, Varnishes, Polishes, &c., by Thomas Bolas, F.C.S., F.I.C. (Dawbarn & Ward.) Illustrated; 6d. net.

Metal-Working, by J. C. Pearson. (Murray.) Illustrated, 2s.

Practical Slide Making, by G. T. Harris, F.R.P.S. (Iliffe.) Illustrated; 1s. net.

Phylogeny of Fusus and Its Allies, by Amadeus W. Grabau. (Smithsonian Institution.)

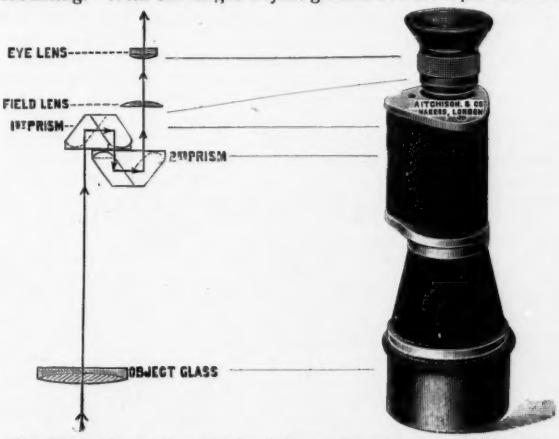
Researches on the Attainment of Very Low Temperatures, by Morris W. Travers, D.Sc. (Smithsonian Institution.)

Nature's Story of the Year, by C. A. Witchell. (Fisher Unwin.) Illustrated; 5s.

Notes on the Composition of Scientific Papers, by T. C. Allbutt, M.A., M.D., &c. (Macmillan.) 3s. net.

The Aitchison Prism Field Glasses.

THE Aitchison Prism Field Glasses, specimens of which have been sent to us for review, represent a considerable adaptability alike of mind and of method on the part of British opticians. The effectiveness and popularity of the Continental prism glasses were such as to leave no doubt in the mind of opticians that in imitation lay the only form of successful competition, and that to imitation must be added improvement. In consequence a great deal of money has been spent with this end in view; and the Aitchison glasses represent a very gratifying measure of achievement as a return on the outlay of expense and ingenuity. The principal features of the glasses that we have before us are the use of large object glasses, variable diaphragms, and improved means of focussing. With the larger object glasses are used prisms and



The Black Line with arrow head shows the path of rays of light in the New Aitchison Prism Field Glass.

lenses of a higher index of refraction than ordinarily employed. The prisms are very much larger than in the German glasses. The introduction of variable diaphragms is a quite new departure in the construction of field glasses. A pair of Iris diaphragms are in this case introduced into the tubes close to the object glasses and ground together so that they are worked simultaneously from the toothed wheel on the central pillar. By this means, as in the photographic camera, all unnecessary rays can be cut off when the light is brilliant, and in dull weather and at night the whole available aperture of the object glasses can be used, thereby effecting an immense advantage over the old form with fixed diaphragms. Another benefit is the rigidity of the body, which is secured by casting the two tubes and crossbars in one piece instead of building them up in separate parts as hitherto.

University College Lectures.

The following Courses of Lectures will be delivered during May at the University College, London.

Course of 16 Lectures on the HISTORY OF MODERN PHILOSOPHY, by Mr. A. WOLF, M.A. First Lecture, April 26th, 4 p.m.

Course of Lectures on COMPARATIVE LAW, by Prof. SIR JOHN MACDONELL, M.A., LL.D., C.B. Commencing April 26th.

Course of 10 Lectures on the HISTORY OF ARCHITECTURAL DEVELOPMENT, by Prof. F. M. SIMPSON. Commencing April 22nd, 11 a.m.

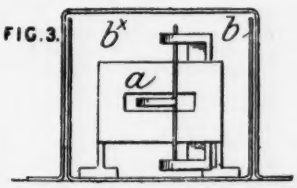
Introductory Course of 12 Lectures on IDEALISTIC ETHICS, by Prof. G. DAWES HICKS, M.A., Ph.D. Tuesdays and Thursdays, 5 p.m. Commencing April 26th.

Course of Eight Lectures on POST-ARISTOTELIAN PHILOSOPHY, by Prof. G. DAWES HICKS, M.A., Ph.D. Tuesdays, 4 p.m. Commencing May 3rd.

Recent Patents.

19,652. Electricity, measuring. NALDER, F. H., and NALDER BROS. AND THOMPSON, 34, Queen Street, London. Sept. 8.

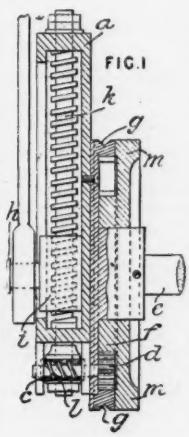
FIG. 3.



Current Meters.—An ammeter or volt-meter, having a soft-iron needle movable about an axis at right-angles to the magnetic axis of a coil *a*, is provided with a magnetic shield *b*, *b** of soft iron or mild steel, which may be enclosed in an ordinary cast-iron casing. The shield has the form of a cubical box surrounding the coil, its ends being open. It may be in two parts, as shown, one overlapping the other tightly. Or it may be in one piece, the ends of which are overlapped.

23,731. Variable-speed mechanism. MEISCHKE-SMITH, W., and MEISCHKE-SMITH, G. F., both of 7, Rue Drouot, Paris. Oct. 30.

FIG. 1



Relates to variable-speed mechanism, particularly for use with motor cars and in connection with friction-ratchet driving-apparatus, such as is described in Specification No. 20,135, A.D. 1902. A crank *a* mounted on a shaft *e* has the crank-pin *h* mounted on a nut *i*, which can move on a screw *k* in the crank *a* for producing a variable throw. The screw *k* terminates in a worm-wheel *l*, which gears with the worm *c* on a short shaft carrying a pinion *d*. The pinion *d* engages with both a loose toothed wheel *f*, and a loose inner toothed ring *g*. The wheel *f* is fixed to the disc *m* so that either *f* or *g* can be retarded by a brake. When either is retarded, the pinion *d* is caused to rotate, and, through it, the screw *k* and the nut *i* relatively to the crank *a*.

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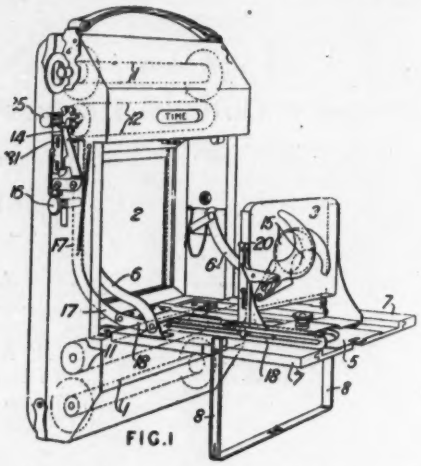
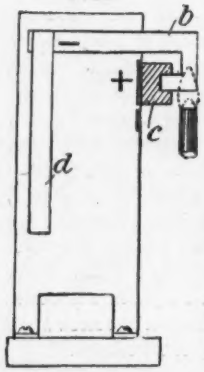
23,733. Photography. BECK, C., 68, Cornhill, London. Oct. 30.



Cameras; roller slides; shutters.—Relates to a camera with roller slide and two shutters, one at the focal plane and one at the lense. The camera is shown in Fig. 1, with the bellows removed. The rollers 12, 11 of the blind shutter are mounted between rollers 1 of the roller slide. The front 3 is mounted on metal runners 5 fixed in the middle of the hinged base-board 7. To fold up the camera, the front 3 is pushed back, the stays 6 are disconnected, and the base-board 7 is folded up on the back. The camera is supported by a metal frame 8, which is pivoted to a base-board 7 so that it can be turned over the end of the latter in folding up the camera. The focussing is done by moving an arrow on the front along a scale of distances on the base-board, lines being marked on each side of the arrow to indicate depths of focus for the different lense apertures. The lense shutter, which consists of two hinged plates 15, is closed while the roller blind shutter is being set by turning the button 25. To make an exposure, the button 16 is depressed, a movement which, acting through the links 17, 18, 20, or through a flexible shaft, opens the shutter 15, then lifts the pawl 14, which releases the roller blind shutter, and makes an exposure. The blind shutter has two apertures, one equal in size to the aperture 2 in the back of the camera, and a narrower aperture for more rapid exposures. There is an adjustable stop arrangement in the blind roller 12 by means of which either of these apertures can be used. This stop arrangement consists of an axial screw actuated by the roller 12 and thus moved lengthwise, till it comes against a stop and arrests the shutter. For a time exposure, the large aperture of the roller blind is brought opposite the opening 2 and held there by the pawl 14, which is locked by a sliding plate 81. The time exposure is then made by the front lense. A method of holding the spools of roller slides so that they can be easily removed or inserted is described. A spring is placed at one end of the spool so that it can be pushed back to liberate the other end.

23,858. Thermo-electric batteries. JOHNSON, J. Y., 47, Lincoln's Inn Fields, London.—(*Wolf & Co., A.; Bleichstrasse, Frankfort-on-the-Main, Germany*). Oct. 31.

FIG.1.

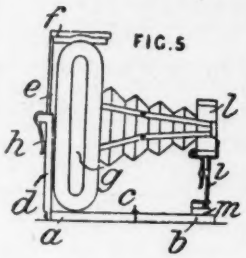


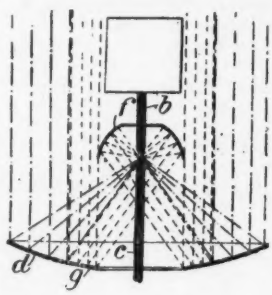
Consists in the employment of special shaped bars for use in a thermo-electric battery. The bar *b*, consisting of a nickel-copper alloy, is bent as shown and has a bar *c* cast on one end, this bar being an antimony-zinc alloy to which iron or cobalt has been added, in order to raise its melting point and to increase its mechanical strength. A copper strip *d* is attached to the nickel at its cold end, to act both as a support for, and to facilitate the cooling of, the nickel, whilst a copper plate is attached to the antimony for the same purpose. The short horizontal and vertical arms of nickel, which are heated to produce the thermo-electric current, may be replaced by silver, or an alloy of copper and silver, or copper coated with silver or gold; or the short horizontal arm alone may be so replaced.

19,749. Photography. BECK, F., 12, Kaiserstrasse, Nuremberg, Germany. Sept. 9.

Camera stands.—Relates to a supporting-device for hand cameras, which is detachable from the camera. It consists of a base-board in two parts *a*, *b* hinged at *c*. At the back of the part *a* is pivoted a bracket *d* having a sliding bar *e* with an arm *f*, which is pressed down on the camera back *g* and clamped by the lever *h*. The front *l* of the camera is held by a spring clip which is pivoted to the front of the part *b*. When the support is not in use, the brackets *d*, *i* are folded down flat, and the parts *a*, *b* are folded together on the hinge *c*. The camera may be laid on its side on the support, when the front *l* rests on the block *m*, and the arm *f* is pushed further down.

FIG.5





23,969. Arc-light projectors. ENGELSMANN, A., 11, Arminstrasse, Stuttgart, Würtemberg, Germany. Nov. 3.

Reflectors for projecting light from alternating-current arc lamps. The light from the carbons *b*, *c* is reflected by two annular parabolic mirrors *d*, *f*, that falling on the mirror *f* being reflected again by an annular mirror *g*, within the mirror *d*.

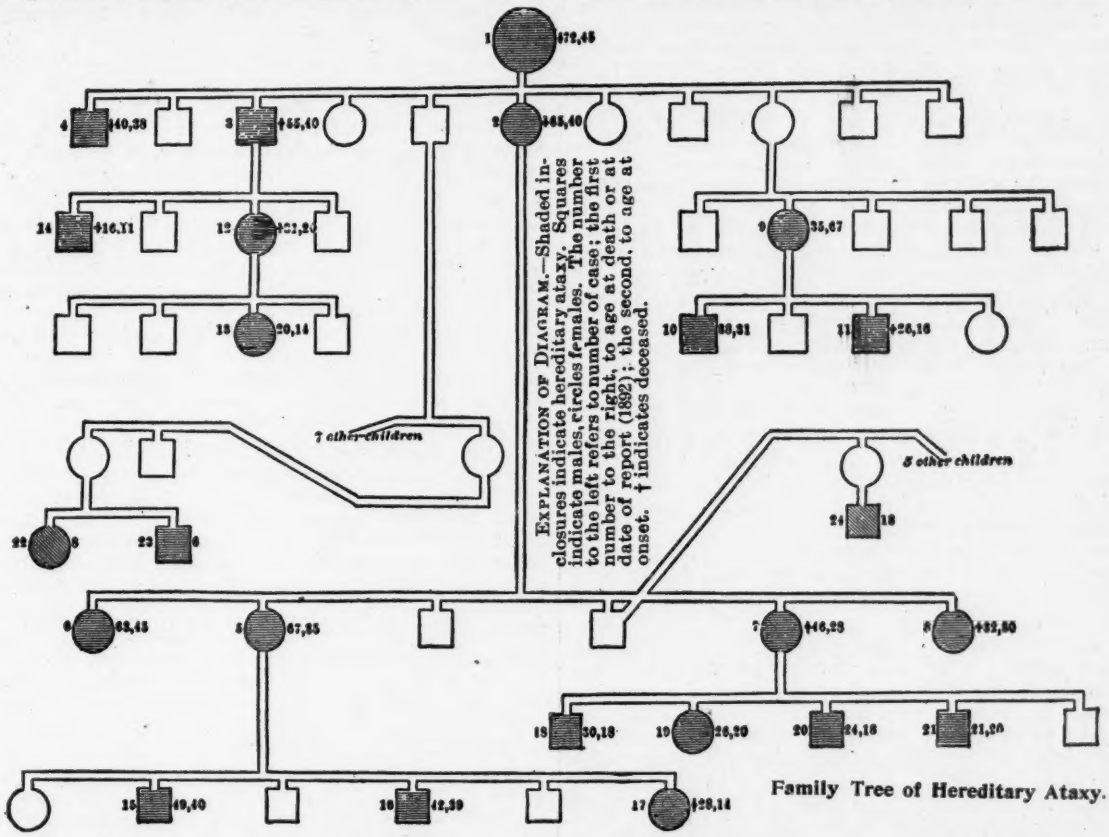
N-Rays Stored up by Certain Bodies.

In the course of his investigations of the N-rays, Professor Blondlot, as pointed out in a note just read before the French Academy of Sciences, happened to state an interesting phenomenon. N-rays being produced by an Auer burner enclosed in a lantern, would traverse first one of the walls formed by an aluminium foil, to be concentrated afterwards by a quartz lense on phosphorescent calcium sulphide. The Auer burner having been extinguished and taken away, the phosphorescence would persist with nearly all its brilliancy, and on interposing a lead screen or moistened paper or else the hand between the lantern and the sulphide, the latter would be darkened; nothing was thus changed by the Auer burner being taken away but for a gradual decrease in the strength of the effect observed. Twenty minutes afterwards, they would still persist though being nearly insensible.

On closer investigating, the conditions of this surprising phenomenon, Blondlot soon noticed that the quartz lense had itself become a source of N-rays; as, in fact, this lense was taken away any action on the sulphide would disappear, whereas by approaching the lense, the sulphide was made to take a higher brilliancy. The author then exposed a quartz plate 15 mm. in thickness, the surface of which was a square of 5 sq. cm. to the action of N-rays given off from an Auer burner through two aluminium foils and black paper, when the plate would become active like the lense; as, in fact, the sulphide was approached, a phenomenon would be observed as if a darkening veil were taken away from it. In all these experiments the secondary emission from the quartz adds its effect to the N-rays directly emanating from the source. This secondary emission resides throughout the mass of the quartz, and not only on its surface, as by placing successively several quartz plates one on another, the effect is found to augment with each added plate. Islandspar, fluorspar, glass, &c., show a similar behaviour. A Nernst lamp filament will remain active for several hours after the lamp has been extinguished. A gold piece, on being laterally approached to the sulphide, submitted to the action of N-rays, would take a higher brilliancy; lead, platinum, silver, zinc, &c., would produce the

same effects. These actions would persist after the extinction of the N-rays, as in the case of quartz, though the property of emitting secondary rays does not penetrate but slowly the masses of metal.

Aluminium, wood, dry and moistened paper, paraffin, &c., do not show this property of storing up N-rays. Calcium sulphide, on the other hand, will exhibit the same effect. This phenomenon accounts for the fact formerly observed by the author that the increase in phosphorescence under the action of N-rays require a certain time both to be produced and to disappear. As, in fact, N-rays are stored up, the different parts of the mass of sulphide will mutually strengthen their phosphorescence; as, however, the storing up is progressive, and as, on the other hand, the amount stored up is not exhausted instantaneously, the effect of N-rays falling on phosphorescent sulphide must increase slowly, and on being eliminated their effect cannot but progressively be extinguished.] Certain stones picked up in a court where they had been exposed to the action of sun rays in the afternoon would give off spontaneously N-rays, preserving this activity for four days without any appreciable decrease. The surface of these bodies should, however, be very dry, the slightest layer of water being sufficient to stop the N-rays.


EXPLANATION OF DIAGRAM.—Shaded inclosures indicate hereditary ataxy. Squares indicate males, circles females. The number to the left refers to number of case; the first number to the right, to age at death or at date of report (1892); the second, to age at onset. † indicates deceased.
7 other children
5 other children

Family Tree of Hereditary Ataxy.

Hereditary Ataxia.

Among the latest volumes of the Decennial Publications of the University of Chicago is an interesting article by Lewellys F. Barker,* which includes a detailed description of the gross and microscopic findings in the brains and spinal cords of two brothers, dead of hereditary ataxia. Coloured plates illustrate the lesions of the spinal cord.

The article in question is extremely interesting to neurologists and medical men, and should be studied by those seeking the truths of well-deep neurological literature.

To the general scientific reader, who does not wish for technical details, the article brings home the lessons of care that parents should take in inquiring into the antecedents of those about to marry.

Dr. Sanger Brown says, and truly says: "Hereditary ataxia is a disease which may be traced through several—at least four—generations, increasing in extent and intensity as it descends, tending to occur earlier in life, and to advance more rapidly. It usually attacks several members of the same family. It occurs most frequently between the ages of 16 and 35. It shows no marked preference for sex, but it descends through females four times as frequently as through males. There is always considerable inco-ordination of all the voluntary muscles, and a sluggishness of the movements which they produce, when the disease is well established. This is usually noticed first in the muscles of the legs, but in a few months or years extends to the arms, face, eyes, head and organs of speech. Sometimes it occurs first in the upper extremities, and sometimes in the organs of speech."

There is little to be noticed in the macroscopic appearance of the cord as shown in the illustrations given, but microscopically, there is revealed marked degeneration in the grey and white matter.

The matter contained in this publication is accurate, and shows a profound insight and knowledge of the disease treated. By its study, we are enabled to know with certainty the neurone-systems principally involved in the individuals who are affected, though we are as yet entirely ignorant as to why just these neurone-systems should be picked out. The letterpress is clear and large, and the plates are extremely well done. We must congratulate the University of Chicago Press Illinois, on the first series of their publications for the University of that city.—S.G.M.

*"A Description of the Brains and Spinal Cords of Two Brothers, Dead of Hereditary Ataxia of the Series in the Family Described by Dr. Sanger Brown," by Lewellys F. Barker. The Decennial Publications of the University of Chicago.

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, F.R.M.S.

MITES.

CECIL WARBURTON, M.A.

WHY do so few people collect mites? If we come to think of it the waste of energy among collectors is appalling, simply because nearly all are content to follow beaten tracks, where the chances of new discoveries are rare, and the same old observation is made for the fifty-thousandth time. There must be hundreds of people in England at this moment whose hobby is the microscope, who are skilful in the manipulation of small objects, and possess the collector's instinct, but whose imagination does not get beyond making neat preparations of diatoms or rotifers, or Foraminifera. And all the time here is a group of creatures ideal for the purpose, of great intrinsic interest, and concerning which a great deal remains to be discovered. Anyone who attacks the Acari with enthusiasm is pretty sure to add not one but many mites to the sum of human knowledge.

Many, no doubt, are deterred by the very fact that so little is known about these creatures. A moth, or a beetle, or a rotifer can generally be identified with comparative ease, because the researches of innumerable workers in these groups have been reduced to a form convenient for reference; but how is one to identify a mite? There is force in this argument, of course, though if the difficulties are greater, the chances of distinction are greater in proportion. In one family of the Acari, the Oribatidæ or "beetle-mites," moreover, this difficulty does not exist. Just consider, for a moment, the following facts.

Hardly a single Oribatid mite was recorded as having been captured in this country before 1879. In that year Mr. A. D. Michael published the first of a series of papers on these creatures, which he has since summed up in an admirable monograph,* fully illustrated, and containing every kind of information which can be of use to the collector. In this about a hundred British species are described. Remember that he was absolutely a pioneer in the subject, and worked at it almost single-handed in the leisure hours of five years of a busy professional life, and that very little indeed has been done since. He has given his followers a magnificent start; but is it likely that the mine he discovered and worked so enthusiastically is anywhere near exhaustion?

It would appear at first sight that the search for creatures which seldom exceed a millimetre in length, and are frequently very much less, must be laborious and irksome. The exact opposite is the case. Certainly it would be out of the question to go out into the open, armed with a lens, in search of individual mites, but there is not the least need for such a proceeding. These mites live under loose bark, in decaying wood, and especially in lichen and moss. The necessary equipment, then, for field work is not a lens at all, but a bag, or several bags. Thus armed the collector starts out to visit some likely spot that has occurred to him, a moss-grown wall, or a coppice where the trees are grey with lichen, and the ground carpeted here and there with patches of moss, and with such materials he fills his bags, bringing them home to work over at leisure.

The study or "den" is now cleared for action. The apparatus consists of a pocket-lens, some large sheets of white paper (the white under-surface of remnants of wall paper is excellent for the purpose), a camel's hair brush, some ordinary microscope slides, and a low-power microscope arranged for opaque objects. I know of nothing better for the work in hand than a Stephenson's binocular with the one-inch objective. Portions of the moss are shaken out over the paper, and the *débris* allowed to remain undisturbed for a minute or so. Then most of the creatures shaken out of the moss will have found their feet, and will not be dislodged if the general litter is gently tilted off or blown aside. Numerous little specks are sure to be left adhering to the paper, and a moment's observation will show that some of them are slowly moving. Then the lens is brought into play, and the moving speck examined, and if it seems to be one of the creatures sought, it is transferred to a slide by means of the brush, and placed under the microscope for a closer study. But there are many other moving specks, and time is too precious just now to spend more than a moment or two over a single example, so we lightly place a cover-slip on his back, and thus loaded he is not likely to have moved very far when we have leisure to look at him again.

If the material is good, the hunt will be found exciting enough while it lasts, and the "bag" will be a certain number of tiny creatures making ineffectual efforts to walk along on the slippery surface of the glass slides under the superincumbent weight of the cover-slips. What is to be done with them? Well, the more thoroughly they can be examined while alive, the better, but those that are selected for the cabinet have to be killed and preserved in some way or other. In a collection of mites it is very desirable to have a double series of specimens, one series mounted as opaque objects, and the other rendered transparent. Whichever their destination, the preliminary operations are the same. The best way to kill them is to pop them into boiling-water. It sounds brutal, but it is instantaneous, and it has the advantage that it causes many species to extend their legs, and those that are not so obliging are generally in a more or less limp condition, and pretty easily manipulated. Now is the moment when the skill of the operator comes in. The mites are taken out of the water with the brush, and placed on white blotting paper. Then a single specimen is placed on a slide, turned on his back, and his legs arranged in the desired attitude under a dissecting microscope. A cover-slip keeps him in the proper position, and a drop of 2% solution of formalin is run in, a slight weight, such as a flattened shot, being superimposed to prevent the legs from curling up again. For the even distribution of the weight it is well to make a tripod with three specimens and the cover-slip.

Next day the creatures will be found to be rigid, and ready for dry mounting. If they are to be made transparent, carbolic acid is substituted for the formalin, which is removed by means of blotting paper as the acid is added. Some species will require a very much longer time in the carbolic acid than others, but they simply remain in till clear, when they are ready for mounting in Canada balsam, and the collector then has one specimen which shows how the animal looks when alive, and another in which minute points of the external anatomy may be studied. In this particular group of mites the chitinous cuticle is generally well-developed,

* Publications of the Royal Society, 2 vols.

and the creatures lend themselves excellently to dry mounting.

Very wet moss will not yield up its inhabitants on shaking, and it must be somewhat dried—not too rapidly. If there is a great deal of coarse *débris*, as is sometimes the case, there is a danger of all the mites being swept off as the paper is tilted, and to obviate this it is not a bad plan to use some wide-meshed muslin as a sifter. The mites and the smaller particles of earth readily pass through the meshes, and can be distributed evenly over the surface of the paper with better chances of successful hunting.

(To be continued.)

Royal Microscopical Society.

March 16.—Dr. Dukinfield H. Scott, F.R.S., President, in the chair. Prof. A. E. Wright communicated the purport of his paper "On Some New Methods of Measuring the Magnifying Power of the Microscope and of Lenses Generally." He described also the piece of apparatus which he had invented for taking the magnifying power of the microscope and for the rapid measurement of microscopic objects, which he termed an Eikonometer. It is placed over the eyepiece, without disturbing any of the adjustments of the instrument, and the object on the stage can then be instantaneously measured. The Secretary read a short note by Mr. E. B. Stringer "On the Separation of Ultra-Violet Light." Mr. Abraham Flatters exhibited on the screen a series of 60 hand-painted lantern slides illustrating botanical histology. The slides were photomicrographs of the actual micro-sections coloured accurately to represent the staining, and were much commended.

Queckett Microscopical Club.

The 412th ordinary meeting of the Club was held on March 18, at 20, Hanover Square, W., the new President, Dr. Edmund J. Spitta, V.P.R.A.S., in the chair. The Secretary announced that the new catalogue of the Club's Library, containing some 1300 volumes, had been published, and was on sale at the price of one shilling.

Mr. T. G. Kingsford exhibited and described some glass tanks which he had constructed by a new method which did not involve the use of cement. These were primarily intended for use as light filters or screens, but they were also adapted for examination of pond life. The sides were formed of glass discs (clock glasses) kept at the desired distance by blocks of rubber cemented to a rubber band. This rubber band formed a lining to a similar band of flexible metal, the ends of which were drawn together by a screw. The pressure of the band upon the edge of the discs made a water-tight joint.

The Secretary read a note on the resolution of *Amphipleura pellucida*, by Lieut.-Col. John Thompson, of Brisbane.

Mr. D. J. Scourfield read a note, communicated by Dr. Vávra, on two Phyllopods from Bohemia, describing the life-history of these curious *Entomostraca*.

The Secretary then read extracts from a highly-technical paper by Mr. T. B. Rosseter, F.R.M.S., "On the Genitalia of Taenia Sinuosa," the remainder of the paper being taken as read.

New Achromatic Condenser.

Messrs. J. Swift and Son have sent me for critical examination a new achromatic condenser of the form which is now rapidly superseding the ordinary non-achromatic type, which

has so small an aplanatic cone as to be nearly useless for really critical work. Messrs. Swift's condenser is achromatic, its power is $\frac{4}{10}$ of an inch, and its aplanatic cone is between ·95 and ·96, with a numerical aperture of 1. With the top lens removed the power is about 1¼ inch, but the aplanatic aperture, as always happens under such circumstances, suffers accordingly, dropping to ·4. The back lens is nearly 1 inch in diameter. It is not generally realised that to obtain the full aplanatic aperture of condensers of so perfect a type a definite thickness of slide must be used, and to obviate this and at the same time enable the best results to be arrived at, Messrs. Swift fit an improved form of correction collar to enable the necessary adjustments to be made. The price of the condenser, without mount, is 48s., and the correction collar is 15s. extra.

Notes and Queries.

I am glad to be able to announce with the present number the resumption of the "Notes and Queries" column, which, owing to circumstances beyond my control, but incident to the pressure of other matter in the columns of this journal, has hitherto been held over. In this column I shall endeavour, as heretofore, to answer (as far as I am able) all questions addressed to me which are of general interest. I wish also, if possible, to give an opportunity to my readers to publish short notes on matters appertaining to microscopy, which may interest them, or on which they may desire to interchange views, though, of course, limitations of space will necessitate my exercising a personal discretion in such matters. On many occasions, by the kindness of various correspondents, my predecessor, Mr. Cross, and I have also been able to distribute micro-material to applicants, and I hope that any readers who may have material of this sort suitable for distribution will give their assistance in this respect.

Magnification of Objectives and Eyepieces. (Major C. W. TATHAM, Devonport.)

A $\frac{1}{12}$-inch objective professes to give an initial magnification (without eyepiece) of 120 diameters *with a 10-inch tube.* If it is corrected for and used with a shorter tube it will give a proportionately lower magnification, *e.g.*, with a 6-inch tube the initial magnification will be $\frac{6}{10}$-ths of the foregoing, *i.e.*, 72 diameters. This magnification is increased by that of the eyepiece, which is, of course, itself unchanged, whatever the tube-length. Thus a $\frac{1}{12}$-inch objective used with an eyepiece that has itself a magnifying power of 5 will give with a 10-inch tube $120 \times 5 = 600$ diameters. With a 6-inch tube the total magnification will be $120 \times \frac{6}{10} \times 5 = 360$ diameters. Now come in two qualifications: First, that the objective is never quite in accordance with its professed magnification (based on the equivalent focal length), and is generally considerably higher second, that the oculars also are not what they profess to be, and, moreover, that many makers will persist in rating them as if they and not the objectives varied in power according to variation in tube-length. For instance, your compensating eyepiece 12 may not be 12, but about half as much again, Zeiss assuming that the $\frac{1}{12}$-inch gives 120 magnifications at 6½ inches, and that this is multiplied by a 12 ocular, making a total of 1440 diameters, whereas, as a matter of fact, with this tube length, the 1440 diameters is made up of objective magnification 72 × ocular magnification 20 or thereabouts! The compensating eyepieces for the long tube are therefore marked with their proper magnifications, and those for the short tube are the same oculars marked down as if they were 6½ times what they really are. With regard to testing the magnifications of objectives and oculars yourself, you will find detailed instructions in my article in the February issue. If you do not follow any point write to me again. Meanwhile, I need scarcely say that any power ocular can be used with any objective, provided the latter will bear it.

Mounting Diatoms in Gum Styrax and Monobromide of Naphthalene. (G. A. EVANS, Bristol.)

I think you will find all that is necessary for mounting diatoms in these highly-refractive media in *Carpenter*, page 521 (8th edition). The gum styrax can be dissolved in benzole or xylol and used as Canada balsam is used, save that more care must be taken to evaporate the benzole, or other solvent, before covering with the cover-glass. Monobromide of naphthalene is soluble in alcohol and ether, but in *Carpenter* it is recommended that the mount should be run round with a ring of wax, then ringed with Heller's porcelain cement (which is not familiar to me), and finally closed with shellac.

[Communications and enquiries on Microscopical matters are invited, and should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge.]

XUM

The Face of the Sky for May.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 4.35, and sets at 7.20; on the 31st he rises at 3.52, and sets at 8.4.

Sunspots and faculæ should be looked for whenever it is fine; the positions of the spots with respect to the equator and pole may be derived from the following table :—

Date.	Axis inclined to W. from N. point.	Centre of disc, S of Sun's equator.
May 1 ..	24° 16′	3° 58′
,, 10 ..	22° 22′	3° 0′
,, 20 ..	19° 36′	1° 52′
,, 30 ..	16° 11′	0° 41′

THE MOON :—

Date.	Phases.	H. M.
May 7 ..	☾ Last Quarter	11 50 a.m.
,, 15 ..	● New Moon	10 58 a.m.
,, 22 ..	☽ First Quarter	10 19 a.m.
,, 29 ..	○ Full Moon	8 55 a.m.
May 8 ..	Apogee	4 18 p.m.
,, 22 ..	Perigee	10 30 p.m.

Occultations.

There are only two occultations of fairly bright stars observable at convenient hours during the whole month. The particulars are as follows:—

Date.	Star's Name.	Magnitude.	Disappearance.	Reappearance.
May 17	130 Tauri	5·5	7.27 p.m.	8.20 p.m.
,, 21	o Leonis	3·8	9. 1 p.m.	9 26 p m.

THE PLANETS.—Mercury will be observable for the first four or five days of the month; he should be looked for in the N.N.W. immediately after sunset at about an altitude of 15°. He is bright enough to be visible to the naked eye, but any slight optical aid will be of great assistance in detecting him in the strong twilight. The planet moves so rapidly that he is in inferior conjunction with the sun on the 13th.

Venus is a morning star throughout the month, rising only a short time in advance of the sun, and being for all practical purposes unobservable.

Mars is in conjunction with the sun on the 30th, and is therefore out of range.

Pallas is in opposition on the 16th, when the magnitude is 8·5. On this date, the minor planet has the same R.A. as γ Herculis, but is situated 6° north of the star.

Jupiter is a morning star, rising about 3 a.m.

Saturn is also a morning star, rising about 1.20 a.m. near the middle of the month; he is in quadrature with the sun on the 11th.

Uranus rises about 11.30 p.m. near the beginning of the month, and about 9.30 p.m. towards the end of the month. The planet is situated 4 mins. E. of 4 Sagittarii, and, observing with a low power eyepiece, can be seen in the same field of view as the star.

Neptune sets too soon for observation.

METEORS.—The principal shower during May is the *Aquarids*. This may be looked for between May 1-6; the radiant being in R.A. 22 h. 32 m., Dec. S. 2°., near the star η Aquarii.

THE STARS.—About 10 p.m. at the middle of the month the following constellations may be observed:

ZENITH . Ursa Major.
NORTH . *Polaris;* to the right, Draco and Cepheus; below, Cassiopeia; Perseus to the left.
SOUTH . Boötes and Virgo, *Arcturus* and *Spica* a little E. of the meridian; Leo to the S.W.
WEST . Gemini and Cancer; Taurus to N.W.; and *Procyon* to S.W.
EAST . Lyra (*Vega*), Corona, Hercules, and Ophiuchus; Cygnus to N.E., and Scorpio in S.E.

TELESCOPIC OBJECTS :—

Double Stars :—α Libræ, XIV.^{h} 46^m, S. 15° 39′, mags. 3, 6; separation 230″; very wide pair.

σ Coronæ, XVI.^{h} 11^m, N. 34° 7′, mags. 6, 6½; separation 4″·4; binary.

α Herculis, XVII.^{h} 10^m, N. 14° 30′, mags. 2½, 6; separation 4″·9. Very pretty double, with good contrast of colours, the brighter component being orange, the other blue.

δ Herculis XVII.^{h} 11^m, N. 24° 57′, mags. 3, 8; separation 17″.

Clusters.—M13 (cluster in Hercules) situated about ⅓ the distance from η to ζ Herculis, and is just visible to the naked eye. It is a globular cluster, and with a 3 or 4-inch telescope the outlying parts of the cluster can be resolved into a conglomeration of stars.

Brass Stripping.

ELECTROLYSIS, which deposits surface films of metal, has lately been put to an ingenious industrial use in stripping metals. Professor C. F. Burgess records a method of stripping superfluous brass from the joints of bicycle frames by using an electric current with a solution of sodium nitrate. The firm which has adopted the method used to make use of hand labour, which damaged the tubes, and afterwards of chemicals, such as potassium cyanide, which were expensive and slow. By this reversal of the principle of electrolytic deposition the brass can be cleaned off the tube joints in from five to forty-five minutes at a scarcely appreciable cost.

Calcium as an Industrial Metal.

PROFESSOR BORCHERS, of Aix-la-Chapelle, has succeeded, after overcoming many difficulties, in producing calcium by a new electrolytic process, by which, it is said, the metal can be obtained at a very low cost. It is now being extracted on a large scale, and there should be a great future before it, for, while of very common occurrence, calcium possesses certain properties, such as a great affinity for oxygen, which should make it a very desirable innovation in the iron industries. Exposed to moist air the metal rapidly becomes coated with oxide; but it nevertheless possesses many characteristics which may prove of value in the arts. It is fairly hard (harder than lead), can be hammered into leaf, and is very light, having a specific gravity of only 1·58, or much less than that of aluminium